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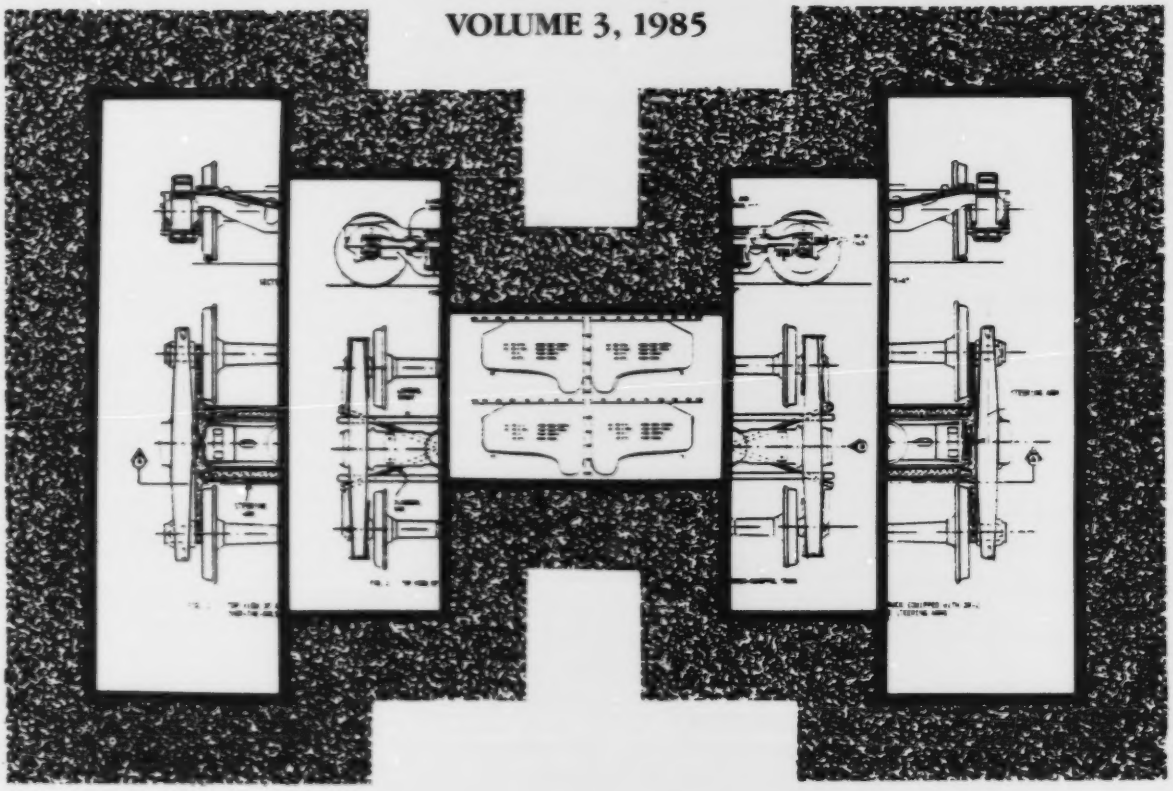
RADIAL AXLE TRUCK TESTS

VOLUME 3, 1985



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TECHNICAL AND OPERATIONS RESEARCH
Canadian Pacific
MONTREAL CANADA

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RADIAL AXLE TRUCK TESTS

VOLUME 3, 1985

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TECHNICAL AND OPERATIONS RESEARCH
Canadian Pacific
MONTREAL, CANADA

August 1986

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"UN SOMMAIRE EN FRANÇAIS EST PRÉSENT DANS CHACUN DES RAPPORTS CI-INCLUS."

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17. Abstract

The Research and Development Department of Canadian Pacific, through a cost sharing agreement with the Transportation Development Centre, continued in-service evaluation of Barber-Scheffel and modified DR-2 self-steering trucks. Static and field tests were also carried out with the 70-ton rigidized elasto-cushion trucks to determine the stresses in the shear plate. This report presents a summary of the in-service test results with the Barber-Scheffel and DR-2 self-steering trucks and discusses field and laboratory test results of the rigidized elasto-cushion truck.

As part of the radial axle truck test program, a series of hunting tests was conducted on the 100-ton UTDC frame-braced trucks, and 70-ton rigidized elasto-cushion trucks. The stability test results for both truck types are presented.

18. Key Words	19. Distribution Statement
Radial axle truck testing, wheel/rail wear assessment, curving and hunting test, Barber-Scheffel trucks, UTDC frame-braced trucks, DR-2 self-steering trucks, rigidized elasto-cushion trucks	A limited number of copies are available upon request from the Transportation Development Centre

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17. Résumé

Aux termes d'un accord de partage des frais conclu avec le Centre de développement des transports, le Service de la recherche et du développement du CP a poursuivi le programme d'évaluation en service des bogies articulés Barber Scheffel et DR-2 modifié. Des essais statiques et in situ ont également été effectués sur des bogies "elasto-cushion" rigidifiés 70 tonnes en vue de déterminer les contraintes sur l'entretoise. Le présent rapport résume les résultats des essais en service effectués sur les bogies articulés Barber Scheffel et DR-2, et traite des résultats des essais en laboratoire et in situ du bogie "elasto-cushion" rigidifié.

Dans le cadre du même programme, les bogies articulés 100 tonnes à liaison croisée des longerons d'UTDC et "elasto-cushion" rigidifiés 70 tonnes ont été soumis à une série d'essais de marche en alignement. Ce rapport présente les résultats des essais de stabilité pour les deux types de bogies.

18. Mots-clés	19. Diffusion
Bogies articulés, essais usure roue/rail, essais en courbe et en alignement, bogie Barber-Scheffel, bogie à liaison croisée des longerons UTDC, bogie DR-2, bogie "elasto-cushion" rigidifié	Le Centre de développement des transports dispose d'un nombre limité d'exemplaires qui seront fournis sur demande

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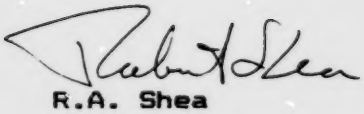
PREFACE

This report presents the results of continued research activities undertaken by the Research and Development Department of Canadian Pacific related to self-steering truck testing.

As a result of earlier tests carried out on a number of premium radial trucks, Canadian Pacific Railway introduced into revenue service testing the two "most promising" self-steering trucks, namely the Barber-Scheffel and DR-2 (similar to DR-1) trucks. This report presents a summary of wheel wear measurements carried out on these radial trucks. The results of field and laboratory tests carried out on the 70-ton rigidized elasto-cushion truck to determine shear plate stress levels and truck interaxle shear and bending stiffnesses are presented. In addition, the results of a series of high speed stability tests conducted on 100-ton UTDC frame braced trucks, and 70-ton rigidized elasto-cushion trucks are also presented.

An extensive research program such as this cannot progress successfully without the active participation and support of others. We would like to acknowledge such support provided by staff of the Mechanical Department of CP Rail, the Vehicle Dynamics Laboratory of the National Research Council of Canada and railway industry colleagues.

Cost shared financial support provided by the Transportation Development Centre (Transport Canada) permitted our activities to be more vigorous than would have otherwise been possible.



R.A. Shea
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IN-SERVICE EVALUATION OF THE BARBER-SCHEFFEL AND DR-2 SELF-STEERING TRUCKS
- AN UPDATE -

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Research and Development
CP Rail
July, 1986

SUMMARY

As a result of earlier tests carried out on a number of premium radial trucks, CP Rail introduced into revenue service testing the two most promising self-steering trucks, namely the Barber-Scheffel and the DR-2 (similar to DR-1) trucks.

Wheel wear measurements found that the Barber-Scheffel and the DR-2 trucks exhibited 20% of the flange wear developed on the control car wheels. Tread wear on wheels of the two radial trucks was about 2/3 the wear developed on wheels of conventional trucks.

Results of a tear-down inspection of the Barber-Scheffel trucks indicated that minimum wear had occurred. The DR-2 steering arm with integral adaptor successfully completed fatigue tests carried out on a laboratory test rig.

SOMMAIRE

A l'issue du programme d'essais sur un certain nombre de bogies articulés, CP Rail a mis en service expérimental payant les deux types de bogies les plus prometteurs: le Barber-Scheffel et le DR-2 qui est un DR-1 modifié.

Par rapport aux roues de bogies classiques témoins, il a été constaté une usure du boudin cinq fois moins élevée et une usure de la surface de roulement réduite d'environ un tiers.

Les bogies Barber-Scheffel ont montré, une fois démontés, un taux d'usure minimal. Par ailleurs, le bras de direction du DR-2 comportant un adapteur intégré a passé avec succès des essais de fatigue réalisés en laboratoire.

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1. BACKGROUND

The Department of Research and Development of CP Rail conducted, in recent years, a series of tests to evaluate the performance of "new generation" freight car trucks.

In 1978 a test plan, consisting of two phases, was formulated in coordination with the Mechanical Department of CP Rail. The first phase consisted of field testing aimed at obtaining quantitative data on the performance of various types of improved truck designs. During this phase, Barber-Scheffel, DR-1, Devine Scales, Swing Motion and Ride control trucks were examined.

The results of Phase I testing indicated that a number of "new generation" truck designs improve both curving and hunting performance compared to existing conventional 3-piece trucks.

As a result of these findings, the two "most promising" self-steering radial trucks, namely the Barber-Scheffel and the DR-2 (similar to DR-1) trucks were chosen for in-service evaluation in unit coal train operation. In 1982, five carsets of bathtub coal cars equipped with the

Barber-Scheffel and another five with DR-2 trucks were introduced to revenue service testing. The results of wheel wear evaluation on wheels of these radial trucks, up to 250,000 miles of service, are presented in this report.

2. IN-SERVICE TESTING OF BARBER-SCHEFFEL TRUCKS

Barber Scheffel trucks were introduced into revenue service testing in January, 1982. They were applied on five 100-ton bathtub coal cars in series CP 352349 to 352443, at CP Rail's Ogden Shops in Calgary. Wheel measurements and truck inspections were made every 60,000 miles.

These trucks have accumulated close to 400,000 miles of service. A truck tear down inspection was carried out at Ogden Shops in Calgary in October, 1984. Measurements of truck bolster bowl diameter and carbody centre plate were collected. Wheel wear measurements were also carried out. Figures 1 and 2 show the wheel tread and flange wear as compared to conventional Barber S2-C trucks.

After 250,000 miles of service operation, the Barber-Scheffel truck wheels exhibit very little flange wear, approximately 1/5 that of the wheels of control cars equipped with conventional trucks. The tread wear on wheels of the

Barber-Scheffel trucks is also lower than conventional truck wheels. After 250,000 miles the tread wear on these radial trucks was found to be 2/3 that of the conventional truck wheels.

The total number of wheelset change-outs, since introduction of these cars to revenue service testing, is seven. Of the seven wheelset change-outs, one was because of shelling and the remaining six were changed out for reasons other than normal wear. This indicates that wheel removals for shelling are much lower with radial trucks compared to conventional truck wheels. The next inspection and wheel wear measurements will be carried out when these cars have accumulated 400,000 miles of service.

Measurements of truck bolster bowl and carbody centre plate revealed, after 250,000 miles, wear in the range of 1/16"-3/64". The AAR condemning limit is 7/8 inches. Roller bearing adaptor thrust shoulder wear was found to be .001-.002 inches. The AAR condemning limit is .025 inches. These data indicate that minimum wear had occurred on Barber Scheffel truck components.

3. THE DR-2 SELF-STEERING TRUCK TESTS

The second truck selected for revenue service evaluation was the DR-2 truck, which is basically a conventional truck with steering arms with over-the-bolster connections and shear pads. In May 1982, five carsets of bathtub coal cars in series CP 352849 to CP 352853 were equipped with the DR-2 trucks at National Steel Car in Hamilton.

These trucks were introduced to revenue service operation on the Pacific Region of CP Rail in June 1982 and were placed together with the special radial truck test consist of Barber-Scheffel and Barber S2-C trucks.

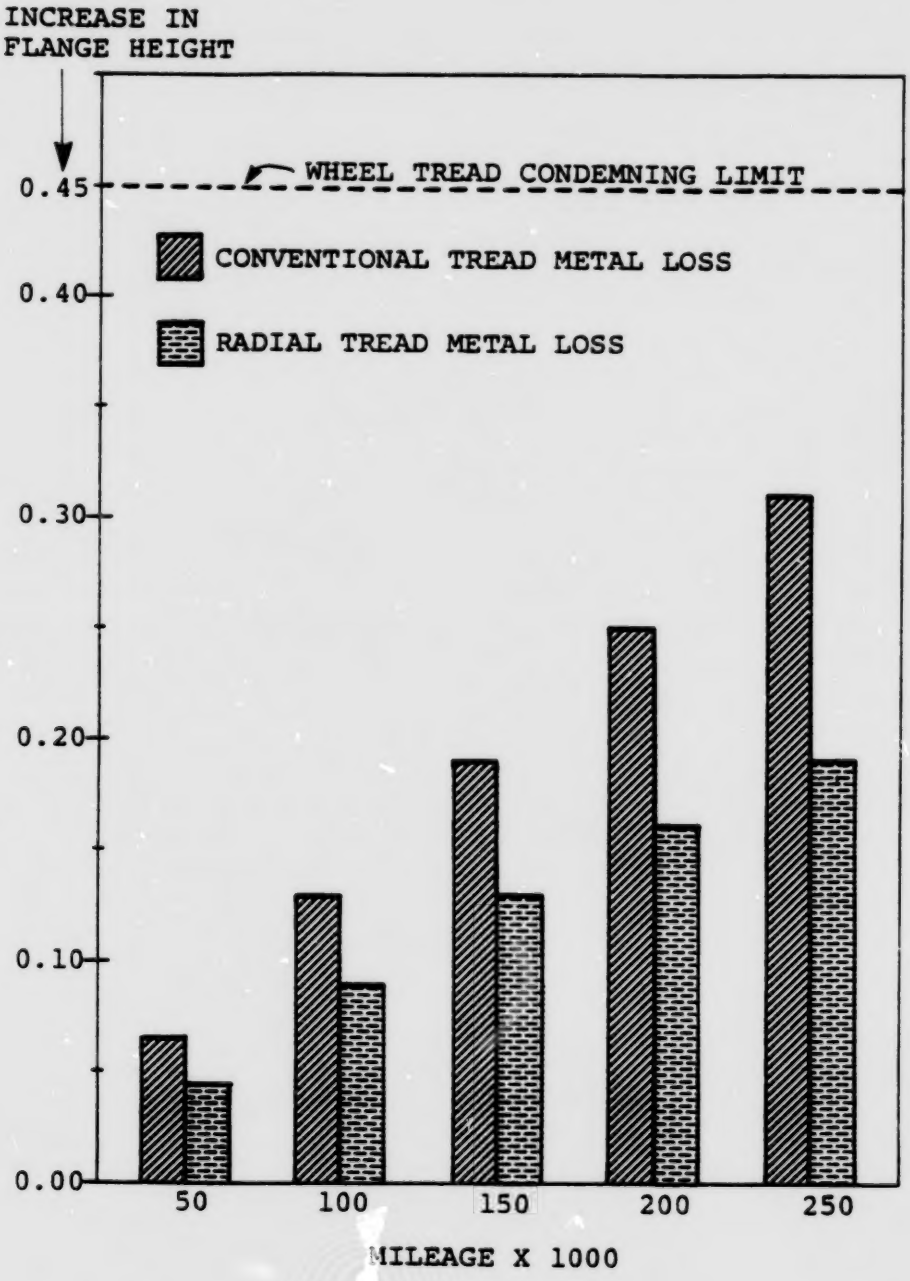
Test cars equipped with DR-2 trucks with steering arms having link connections accumulated approximately 130,000 miles of service when an inspection revealed that the links connecting the steering arms were failing. Even though problems were experienced with the steering links of the DR-2 trucks, the flange metal loss was considerably lower for the DR-2 truck wheels compared to conventional truck wheels. Wheels of both the DR-2 and the Barber-Scheffel trucks exhibited approximately 20% of the flange wear developed on the control car wheels. The tread wear on wheels of the DR-2 trucks was also about 2/3 the wear developed on wheels of conventional trucks.

The DR-2 self-steering trucks were re-introduced into revenue service testing with a new design of the steering arm connection incorporating a pin/bushing arrangement. These cars have now accumulated approximately 150,000 miles of service in unit coal train operation in the Pacific Region of CP Rail. Two field inspections were carried out in 1985 at Revelstoke B.C. Inspections revealed that four of the eight pin/bushings connections exhibited some movement of the rubber bushing. These connections will be modified with the addition of grooves to secure the spring retaining rings required to prevent movement of the bushing.

The need to quantify the DR-2 steering arm in-service load environment for use in fatigue testing of the steering arm prompted CP Rail research to collaborate with Dofasco to collect these data. Field tests were carried out with coal cars CP 352852 and CP 352853 to measure the magnitude and frequency of occurrence of DR-2 steering arm lateral and torque loads.

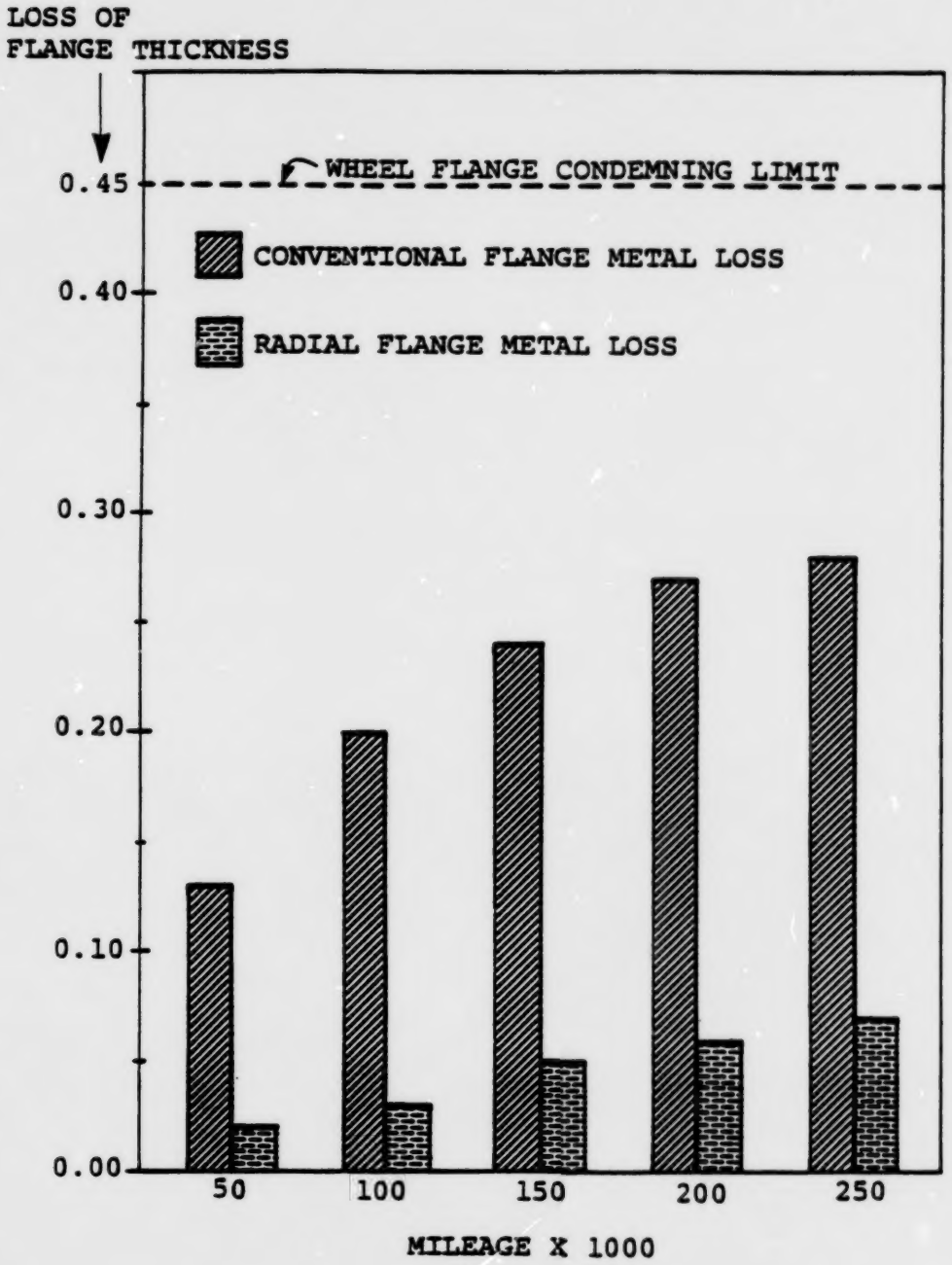
The load spectrum obtained from the instrumented DR-2 steering arm indicated that a maximum alternating load of 11,250 lbs. and a maximum alternating deflection of 0.972 inches occurred during loaded unit coal train return trip from Fording to Revelstoke on the Pacific Region.

Fatigue tests were carried out on the DR-2 steering arm at Dofasco's laboratory where a special fatigue test rig had been set up. The load environment on the DR-2 steering arm collected during the service testing was utilized to reconstruct field conditions in the laboratory tests. The length of the test was based on AAR guidelines of a 3 million mile life for unit coal train equipment. The steering arm with integral adaptor successfully completed the fatigue tests.



INCREASE IN FLANGE HEIGHT VS MILEAGE
(BARBER-SCHEFFEL)

Figure 1



LOSS OF FLANGE THICKNESS VS MILEAGE
(BARBER-SCHEFFEL)

Figure 2

STATIC AND FIELD TESTS TO DETERMINE STRESSES IN SHEAR PLATE OF A RIGIDIZED ELASTO-CUSHION TRUCK

R.F. Gonsalves
Research and Development
CP Rail
Report No. T-908-86
February, 1986

SUMMARY

Static tests were carried out on one rigidized elasto-cushion truck to determine the stress levels in the shear plate of the truck. The static tests were conducted at the National Research Council Railway Laboratory and consisted of the application of an interaxle lateral load to the truck under a laden car. In addition, the test truck was subjected to a twist input to simulate tne effect of rail joints. On completion of the static tests, a revenue service test was conducted between Ottawa and Trois Rivieres to measure dynamic stress levels on the shear plate of one rigidized elasto-cushion truck with laden 70-ton gondola car CP 337026. The test was carried out on track with 39' rail with staggered rail joints.

Bending and shear stress measured on the shear plate of the test truck during the static and revenue service tests were less than 2000 psi. Higher stresses were measured near the weld of the shear plate. Stress on the shear plate of the rigidized elasto-cushion truck during the revenue service test, due to a combination of lateral loads and a twist input from rail joints, exceeded 10,000 psi near the welds. Further laboratory tests would be required to locate and determine the stress concentration on the welds of the shear plate.

The rigidized elasto-cushion truck has improved interaxle shear stiffness over a conventional truck. Stability tests conducted previously did confirm an improvement in stability over conventional trucks. However, as the earlier tests were carried out under a relatively heavy empty car with moderately service worn wheels, it is recommended that the rigidized elasto-cushion truck be tested for stability with more severely service worn wheels with a light-weight empty car to determine if the interaxle shear stiffness of the rigidized elasto-cushion truck is sufficient to ensure stability. If the stability of the truck is ensured, detailed structural tests should be carried out to locate stress concentrations.

SOMMAIRE

Des essais statiques ont été effectués sur un bogie "elasto-cushion" rigidifié en vue de déterminer les niveaux de contrainte dans l'entretoise du bogie. Les essais qui ont eu lieu au laboratoire ferroviaire du Conseil national de recherches ont consisté à appliquer une charge latérale entre les essieux d'un bogie placé sous un wagon chargé. De plus, le bogie a été soumis à des efforts de torsion pour simuler les effets des joints de rail. Après les essais statiques, on a procédé à un essais d'évaluation en service, entre Ottawa et Trois-Rivières, pour mesurer les niveaux de contrainte dynamique dans l'entretoise d'un bogie "elasto-cushion" rigidifié équipant un wagon-tombereau 70 tonnes chargé (CP 337026). Les essais ont été effectués sur une voie dont les rails mesuraient 39 pieds de long et dont les joints de rails étaient décalés.

Les contraintes de cisaillement et de flexion mesurées sur l'entretoise du bogie n'ont jamais dépassé 2 000 lb/po^2, ni aux essais statiques ni aux essais en service. Toutefois, des contraintes plus élevées ont été mesurées près des soudures de l'entretoise. En fait, elles y ont dépassé 10 000 lb/po^2, à cause de la combinaison des charges latérales et de l'effort de torsion induit par les joints de rail. Il faudra procéder à d'autres essais en laboratoire pour localiser et quantifier les contraintes maximales dans les soudures de l'entretoise.

Comparativement au bogie classique, le bogie "elasto-cushion" rigidifié offre une meilleure résistance au cisaillement entre les essieux. Des essais de stabilité antérieurs avaient déjà révélé ce fait, mais comme ils avaient été effectués avec des wagons vides relativement lourds et des roues modérément usées en service, on recommande de les reprendre avec des roues plus usées en service et un wagon vide léger afin de déterminer si la résistance au cisaillement entre les essieux du bogie est suffisante pour assurer sa stabilité. Dans l'affirmative, on devrait procéder à des essais de résistance détaillés en vue de localiser les contraintes maximales.

ACKNOWLEDGEMENTS

The Research and Development Department of CP Rail acknowledges the contribution of the National Research Council Railway Laboratory, Division of Mechanical Engineering for assistance in conducting the tests.

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1.0 INTRODUCTION

This study was initiated to determine static and dynamic stress levels in the shear plate of a rigidized elasto-cushion truck. Previous tests conducted by Research and Development showed the stiffness characteristics of a rigidized elasto-cushion truck for 70-ton car application (Reference 1) had improved interaxle shear and yaw stiffness in comparison to a conventional 70-ton truck. Furthermore, preliminary tests carried out with 70-ton rigidized elasto-cushion trucks showed that it was a viable method of improving both curving and stability of conventional 70-ton trucks (Reference 2).

In further development of the rigidized elasto-cushion truck for 70-ton car application, the shear plate of one rigidized elasto-cushion truck was strain gauged at the National Research Council Railway Laboratory in Ottawa. The test objective was to determine general stress levels in the shear plate by conducting static tests to simulate the effect of interaxle lateral loads and rail joints. In addition, a revenue service test was carried out with a laden 70-ton gondola car to quantify dynamic stresses in the shear plate. This report documents the methodology, observations and results of these tests.

2.0 RIGIDIZED ELASTO-CUSHION TRUCK DESCRIPTION

The concept of a rigidized elasto-cushion truck for 70-ton car application as proposed by Mr. H. List of Railway Engineering Associates consists of a conventional truck rigidized by means of a shear plate applied between the sideframes of the truck to prevent sideframe parallelogramming. Elastomeric shear pads of 25,000 lb/in stiffness are inserted between the bearing adaptors and the sideframe pedestal roof. The shear plate is bolted to sideframe extensions which are welded to the truck sideframes as illustrated in Figure 1.

3.0 INSTRUMENTATION

The shear plate of one rigidized elasto-cushion truck was strain gauged as illustrated in Figure 1. Shear stress was measured at the plate centre. Bending stress was measured on one sideframe extension. In addition, a strain gauge rosette on one sideframe extension near a plug weld was used to determine general stress levels near a weld.

4.0 OBSERVATIONS AND TEST RESULTS

4.1 Static Tests

Static tests were carried out with a laden car to determine stresses in the shear plate due to the application of interaxle lateral loads and due to a twist of the shear plate, applied by raising one wheel of the test truck, simulating the effect of rail joints.

To apply an interaxle lateral load to the test truck the car was placed in the National Research Council Railway Laboratory. The first axle was clamped to a moveable table on ball bearings which were free to move laterally and yaw without constraint. The second axle of the test truck was clamped to a fixed rail adjacent to the moveable table. The lateral load was applied through an actuator clamped to the bearing of the first axle. The lateral force was cycled in 1000 lb. increments to a maximum of 7000 lbs and the strains in the shear plate were recorded.

To simulate the effect of a twist input to the truck from rail joints, one wheel of the test truck was raised vertically against the weight of the laden car in 1/2" increments from the top of the rail to a maximum of 2" and corresponding strains in the shear plate were recorded.

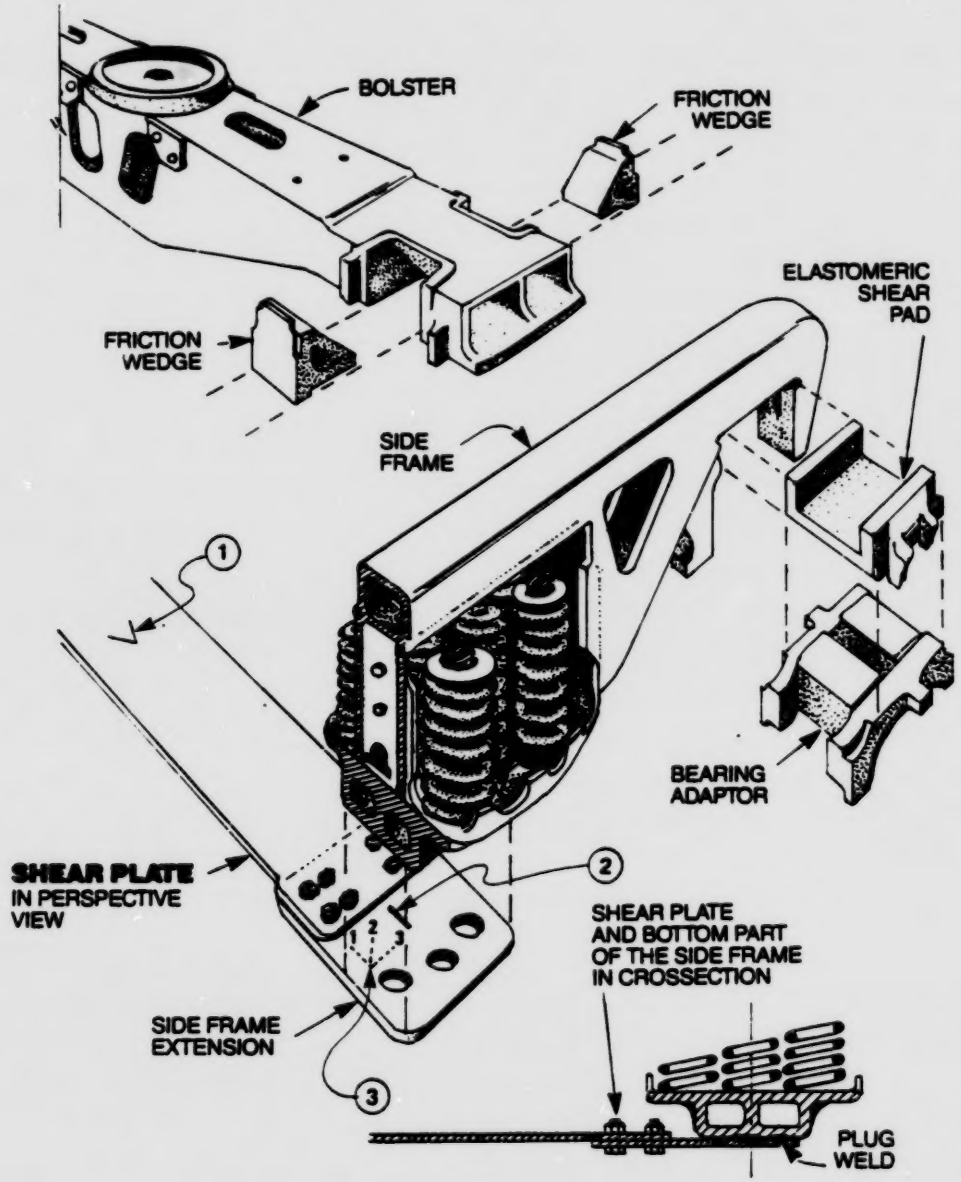
Maximum stresses measured on the shear plate during the static test due to application of an interaxle lateral load and due to a twist input to the truck are tabulated in Table 1. Shear stress at the plate centre and bending stress on a sideframe extension plate were less than 1700 psi. For a 2" wheel lift the stress recorded near one of the plug welds was 6000 psi.

4.2 Revenue Service Test

Laden gondola car CP 337026 with rigidized elasto-cushion trucks was tested between Ottawa and Trois Rivieres on the Lachute and Quebec Subdivisions. The track over which the tests were conducted had maximum curvatures of 4° and consisted of 39' rail with staggered joints. Data was recorded over approximately 50 miles on the two subdivisions at a maximum train speed of 45 mph.

Data from the revenue service test was analyzed using a Datamyte 400 real time Rainflow program to develop a two dimensional, i.e. mean and range histogram of stress levels on the shear plate. The output of the datamyte 400 gives the number of times a certain range-mean combination occurs.

From the data analyzed, the maximum range of dynamic stresses measured on the shear plate of a rigidized elasto-cushion truck are presented in Table 1. Bending and shear stresses on the shear plate of the rigidized elasto-cushion truck were low and did not exceed 2000 psi. Of primary concern are the stress levels near the weld, where some stress cycles did exceed 10,000 psi. Instrumentation problems were experienced with one of the strain gauge rosette near the weld and only data from two strain gauges of the strain gauge rosette are summarized in Appendix 1. This summary in Appendix I shows the total number of occurrences of a specific half range or alternating stress over the 50 mile section that the data was analyzed regardless of the mean stress.



RIGIDIZED ELASTO CUSHION TRUCK

(1) Shear Stress on Plate: Four arm bridge, two gauges on top and two directly below at plate centre.

(2) Bending Stess on Sideframe Extension : Two arm bridge, one gauge on top and one directly below.

(3) Sideframe Extension : Rosette strain gauge near plug weld.

Figure 1

Table 1

Maximum Stress Levels in Shear Plate - Static Tests

	Shear Stress Plate Centre	Sideframe Extension Bending Stress	Rosette on Sideframe Extension Near Weld		
			Gage 1	Gage 2	Gage 3
	psi	psi	psi	psi	psi
Static stress in shear plate due to weight of laden car	190	388	411	1080	2220
Stress in shear plate due to interaxle lateral force of 7000 lbs applied at wheelset bearing of one truck	1128	1248	3558	2070	887
Stress in shear plate due to jacking one wheel of the test truck 2" above the rail against the weight of a laden carbody	360	1600	5640	6000	2010

Note: For location of gages on shear plate refer to Figure 1.

Table 2

Maximum Range of Dynamic Stress on Shear Plate
of Rigidized Elasto-Cushion Truck

Type of Measurement and Location	Maximum Stress psi	Minimum Stress psi
Shear stress, measurement at centre of shear plate	1310	-840
Bending stress, measured on sideframe extension	1895	-1895
Rosette strain gauge, located near plug weld on sideframe extension		
Gage 1	13104	-7488
Gage 2	- *	- *
Gage 3	14040	-14040

Note: For location of strain gages on shear plate refer to Fig. 1.

* Instrumentation difficulties experienced with gage 2.

5.0 CONCLUSIONS AND RECOMMENDATIONS

1. Shear and bending stress on the shear plate of the rigidized elasto-cushion truck during static laboratory and revenue service testing were less than 2000 psi.

2. Of primary importance are stresses at the welds of the shear plate which result from a combination of lateral loads as well as twist input from rail joints. Preliminary stress measurements during the revenue service tests showed that the stress cycles near a weld sometimes exceed 10,000 psi. Further laboratory tests would be required to determine its effect on the welds.

3. Improved interaxle shear stiffness of the rigidized elasto-cushion truck over a conventional truck (Ref. 1) and stability tests conducted previously (Ref. 2) did confirm an improvement in stability over conventional trucks. However, as the earlier stability tests were carried out with a relatively heavy empty car, it is recommended that the rigidized elasto-cushion trucks be tested for stability with severely worn wheels with a light weight car prior to further development work on these trucks.

REFERENCES

1. W. Pak, "Interaxle Shear and Bending Stiffness Tests on 70-Ton Rigidized Elasto-Cushion Truck", Department of Research, CP Rail Report No. T-891-85, October 1985.

2. R.F. Gonsalves, G. Izbinsky, D. D'Aoust "UTDC Frame Braced Rigidized Elasto-Cushion and Elasto-Cushion Truck Tests", Planning and Research Department, CP Limited Report No. T-864-85, May 1985.

Appendix 1

Summary - Alternating stress cycles recorded on 50 mile test section for rosette strain gauge located near weld on shear plate of rigidized elasto-cushion truck (Fig. 1)

± Alternating Stress psi	Number of cycles for each gauge of strain gauge rosette	
	Gauge 1	Gauge 3
1404	27,386	9,457
1872	20,818	1,776
2340	12,692	469
2808	16,766	106
3276	4,722	16
3744	3,054	5
4212	1,800	5
4680	1,021	1
5148	655	-
5616	320	-
6084	208	-
6552	130	1
7020	118	1
7488	30	-
7956	23	-
8424	12	-
8892	3	-
9360	3	-
9828	3	-
10296	1	-
12168	1	-
14048	-	1

Note: Instrumentation difficulties experienced with Gauge 2.

INTERAXLE SHEAR AND BENDING STIFFNESS TESTS ON 70-TON RIGIDIZED ELASTO-CUSHION TRUCKS

W. Pak
Department of Research
CP Rail
Report No. T-891-85
October, 1985

Executive Summary

This report summarizes development of measurement techniques and the results of interaxle shear and bending stiffness measurements for a conventional truck, a rigidized elasto-cushion truck, and for some intermediate configurations between the two.

The results indicate that a considerable increase in interaxle shear stiffness is achieved on the rigidized elasto-cushion truck through the addition of a shear plate arrangement. Increasing the friction wedge preload on a conventional truck increases truck frame squareness against parallelogramming forces.

SOMMAIRE

Ce rapport résume les travaux d'élaboration des techniques de mesure et les résultats des mesures de résistance au cisaillement et à la flexion entre les essieux d'un bogie classique, d'un bogie "elasto-cushion" rigidifié et de certaines configurations intermédiaires.

Les résultats indiquent qu'on a pu obtenir un accroissement marqué de la résistance au cisaillement entre les essieux sur le bogie "elasto-cushion" rigidifié grâce à l'addition d'une entretoise. Dans le cas d'un bogie classique, un accroissement de la précharge du patin stabilisateur fait augmenter la résistance du châssis à la déformation.

Acknowledgements

The CP Research Department acknowledges the contribution of the National Research Council Railway Laboratory, Division of Mechanical Engineering for assistance in conducting the tests.

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1. Introduction

As part of a program to develop a rigidized elasto-cushion truck, a series of truck planar stiffness tests was conducted by the Research Department at the National Research Council Railway Laboratory on an experimental 70 ton freight truck retrofitted to a rigidized elasto-cushion configuration during May and June 1985.

In this series of tests the interaxle bending and shear stiffnesses were measured between the 2 axles of the truck. Interaxle shear stiffness is defined as the lateral stiffness between the 2 axles of a truck resisting parallelogramming. The interaxle bending stiffness is the stiffness between the 2 axles resisting relative bending action. High interaxle shear stiffness is desirable for truck stability and low bending stiffness is desirable for good curving behaviour.

The 70 ton modified truck with LC pads and shear plate was tested first. Modifications were removed, one at a time, to return the truck to a conventional 70 ton truck. In the last test, the friction wedges were removed as well. Interaxle shear stiffness was measured for all intermediate truck configurations to provide additional information.

2. Modified Truck Description

The rigidized elasto-cushion truck is basically a conventional 70 ton freight truck with added Lord LC pads (shear rate 25,000 lbs/in P/N J12449-11) in the pedestal roof area and a shear plate bolted to side frame extensions across the underside of the side frames to rigidize the side frames to prevent frame parallelogramming (Fig. 1). This concept was proposed by Mr. H. List of Railway Engineering Associates. Previous curving and hunting tests conducted by CP Rail indicated superior curving and hunting behaviour of this modified truck compared with normal 3-piece freight car trucks (Ref. 1). The bolster springs are D3, 5 outer and 4 inner, with B421 and B422 as outer and inner friction wedge side springs respectively.

3. General Test Procedure

3.1 Interaxle Shear Stiffness Measurement (Fig. 2,3)

The interaxle shear rate was determined by jacking one axle laterally relative to the other fixed axle and calculating the interaxle shear displacements from longitudinal and lateral movements of the bearings. A loaded gondola car with the modified trucks was placed with the first axle clamped to a floating table resting on ball bearings at the NRC Railway Laboratory. The table was designed to freely translate laterally and rotate without constraint forces. The second axle was firmly clamped to the fixed track section immediately adjoining the floating table. A lateral actuator was clamped to the bearing on the front axle to react against the side wall bulkhead. The centre plate of the test truck was well lubricated.

Dial gauges were set up to measure the axle bearing movements against an externally fixed reference to ground. The actuator force was cycled from positive 7,000~8,000 lbs to negative 7000~8,000 lbs in steps of 1,000 lbs while concurrently taking bearing movement readings. The computation procedure for interaxle shear displacement is shown on Fig. 4.

3.2 Interaxle Bending Stiffness Measurement (Fig. 3)

The bending stiffness of the truck was determined using a different test set up to impart a known torque to the floating front axle against the rear fixed axle. The relative yaw angles of the axles measured for different torques were determined from the interaxle bending displacements.

To impart the proper torque to the axles, the following arrangement devised by Mr. C.A.M. Smith of the NRC Railway Laboratory was used. The front axle was clamped to the floating table as before, and the rear axle clamped to the fixed track. The lateral actuator was placed 46" ahead of the front axle against the floating table Fig. 3, with a link holding the table laterally at the front axles. Both actuator and link were located in the same horizontal plane at ground level. All connectors on the link and actuator were swivel headed. This set up imparts a pure torque to the front axle.

4. Discussion of Results

4.1 Interaxle Shear Stiffness

The interaxle shear displacements vs actuator forces for different truck configurations are illustrated from Fig. 5 to Fig. 9. The interaxle bending stiffness was measured for the rigidized elasto-cushioned truck under the light weight condition only and is shown on Fig. 10. Different interaxle shear stiffness measured for various truck configurations are as follows:

4.1.1 Rigidized Elasto-Cushion Truck Configuration

Fig. 5 illustrates both light and fully loaded cases. The light car case was done with the loaded car body lifted off the truck enough to achieve the light weight bolster spring deflection. The interaxle shear stiffness graphs for the 2 cases are similar with the loaded car case stiffer in the initial deflection range of the rubber pads. The stiffening effect at higher forces is due to the fact that pedestal lateral clearances are exhausted. Fig. 6 is the loaded car case again, except with higher force range and the truck friction wedges removed. The interaxle shear stiffness calculated is approximately 10,000 lbs/in.

4.1.2 Conventional Truck Configuration With LC Pads

In the second test phase the bottom shear plate between the side frames was disconnected, leaving the rubber pads in the pedestals. This type of truck suspension configuration was investigated by CP Research previously, and was found to be unstable with service worn wheels at low speeds (Ref. 1).

Fig. 7 illustrates the interaxle stiffness of the loaded case of such configuration. It can be seen that the interaxle shear rate is relatively low compared to the previous case. The flexibility of the system comes from both the flexibility in the rubber pads in the pedestal and the flexibility of the two side frames to parallelogram simultaneously under lateral axle loads.

4.1.3 Conventional Truck

In the next test, the rubber pads in the pedestals were removed, restoring the truck to a conventional 3-piece truck. Interaxle shear stiffness results indicate large hysteresis, (Fig. 8), typical of friction damping. Frictional type forces were generated during initial force and force reversal, resulting in high stiffness. Once the friction force is exceeded, the stiffness of the truck to resist parallelogramming is very low.

The source of the friction measured can be attributed to the friction wedge preload which is a function of side spring rate and deflection. With a loaded car, this friction level is considerable higher as expected. This could be the reason for better stability generally observed in loaded versus empty freight cars.

4.1.4 Conventional Truck Without Friction Wedges (Fig. 9)

As a final step in the interaxle shear stiffness tests, the wedges in the bolster pockets were removed. The truck exhibited extremely low shear stiffness with little friction hysteresis. This confirms the action of the friction wedges in contributing to stiffness as described in the last paragraph.

4.2 Interaxle Bending Stiffness

The interaxle bending test results for the rigidized elasto-cushioned truck under the empty car case is shown in Figure 10. The interaxle yaw stiffness calculated, as per formula shown in Fig. 4 for the small actuator forces, is approximately 3.0×10^7 in-lb/rad.

References

1. R. Gonsalves, G. Izbinsky and H. Soares, "Hunting and Curving Performance of Rigidized Elasto-Cushion Trucks".

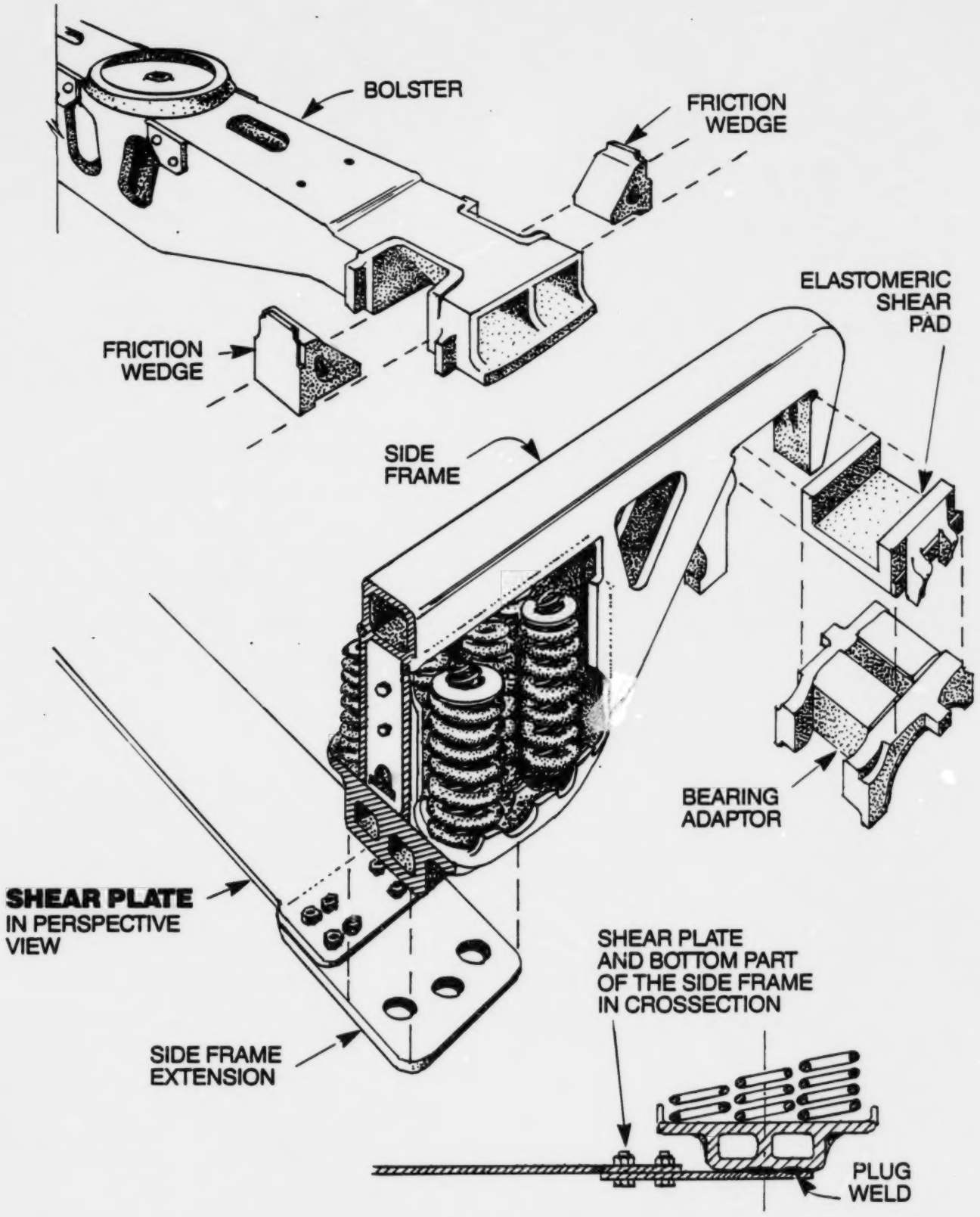


Fig. 1: **RIGIDIZED ELASTO CUSHION TRUCK**

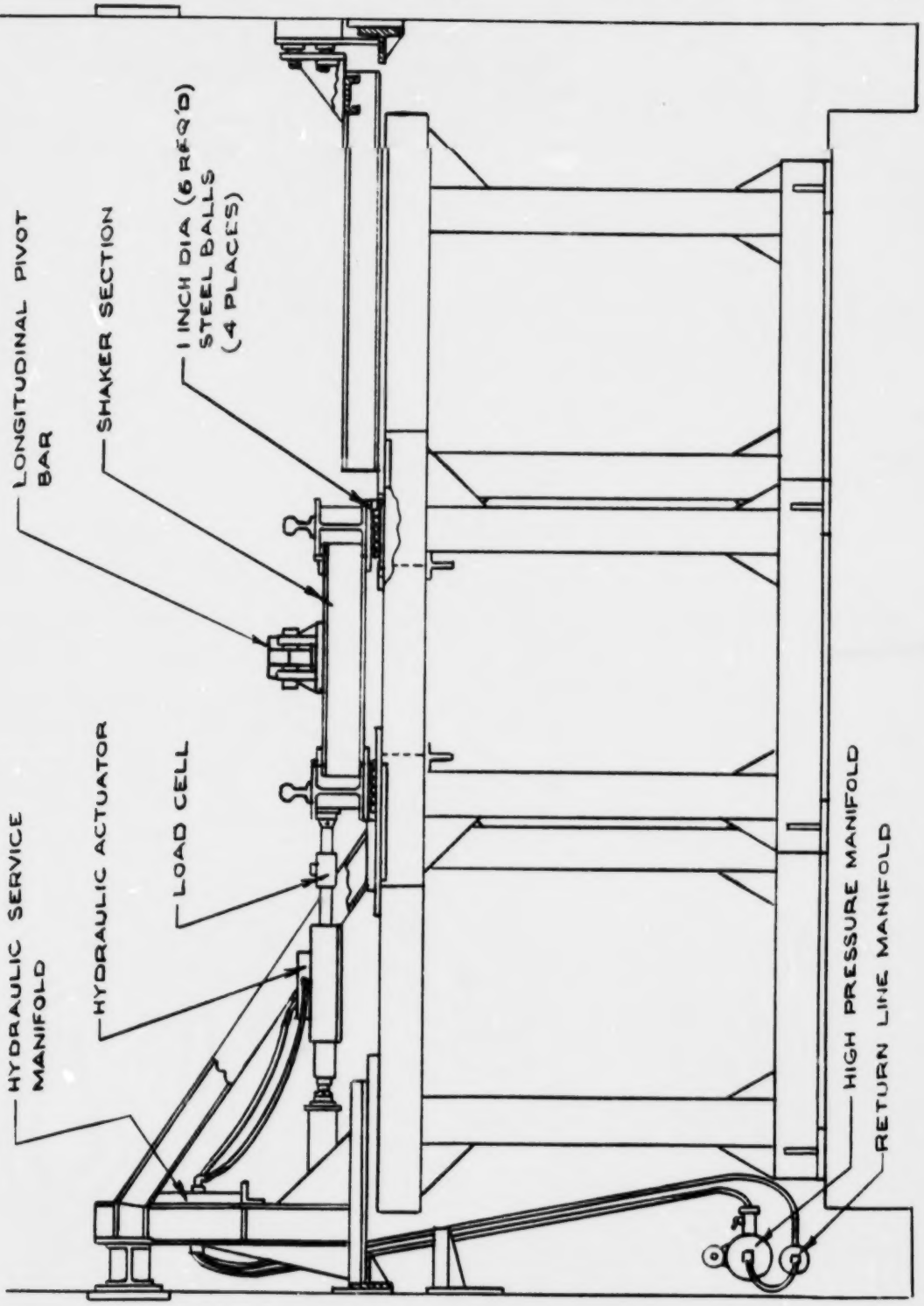
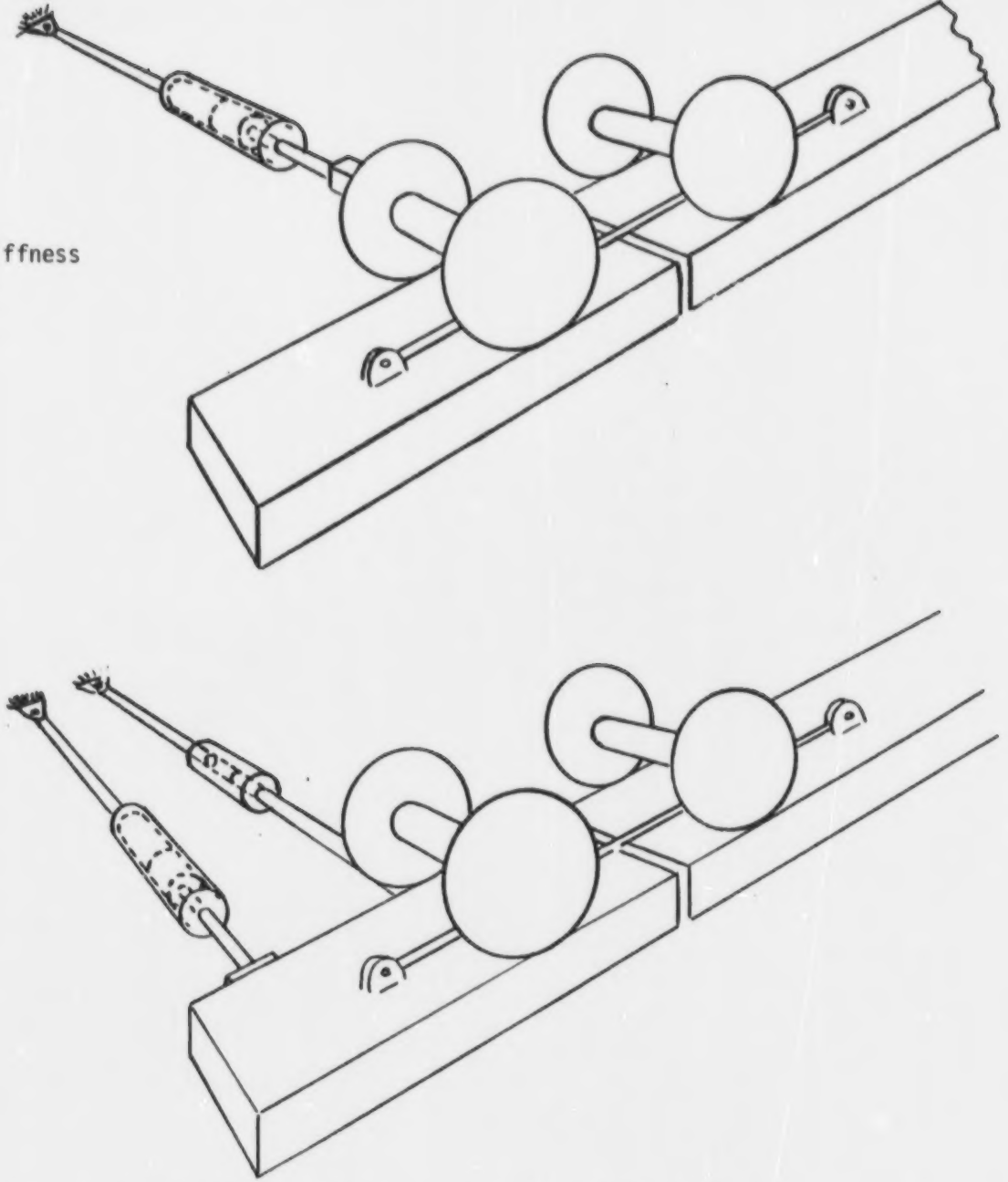


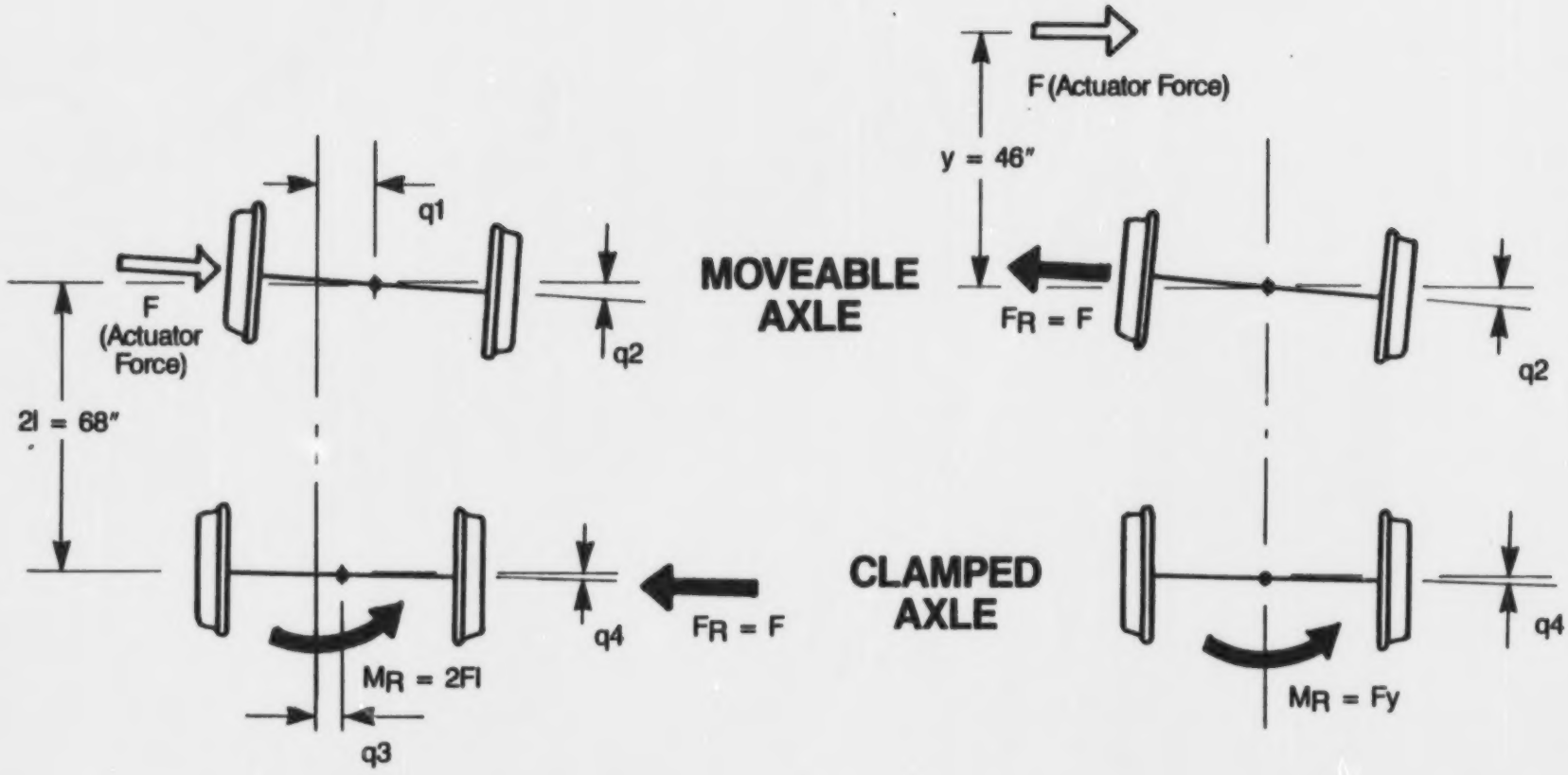
Fig. 2: NRC FLOATING TABLE SET-UP IN RAILWAY LABORATORY



Interface Shear Stiffness
Measurement Set-Up

Interaxle Bending
Stiffness Set-Up

Fig. 3: SCHEMATICS OF INTERAXLE STIFFNESS MEASUREMENT SET-UP



Interaxle Shear Stiffness	=	$\frac{F}{q1 - lq2 - q3 - lq4}$

Interaxle Yaw Stiffness	=	$\frac{Fy}{q2 - q4}$

Fig. 4 : EXPRESSION FOR THE INTERAXLE STIFFNESS COEFFICIENTS

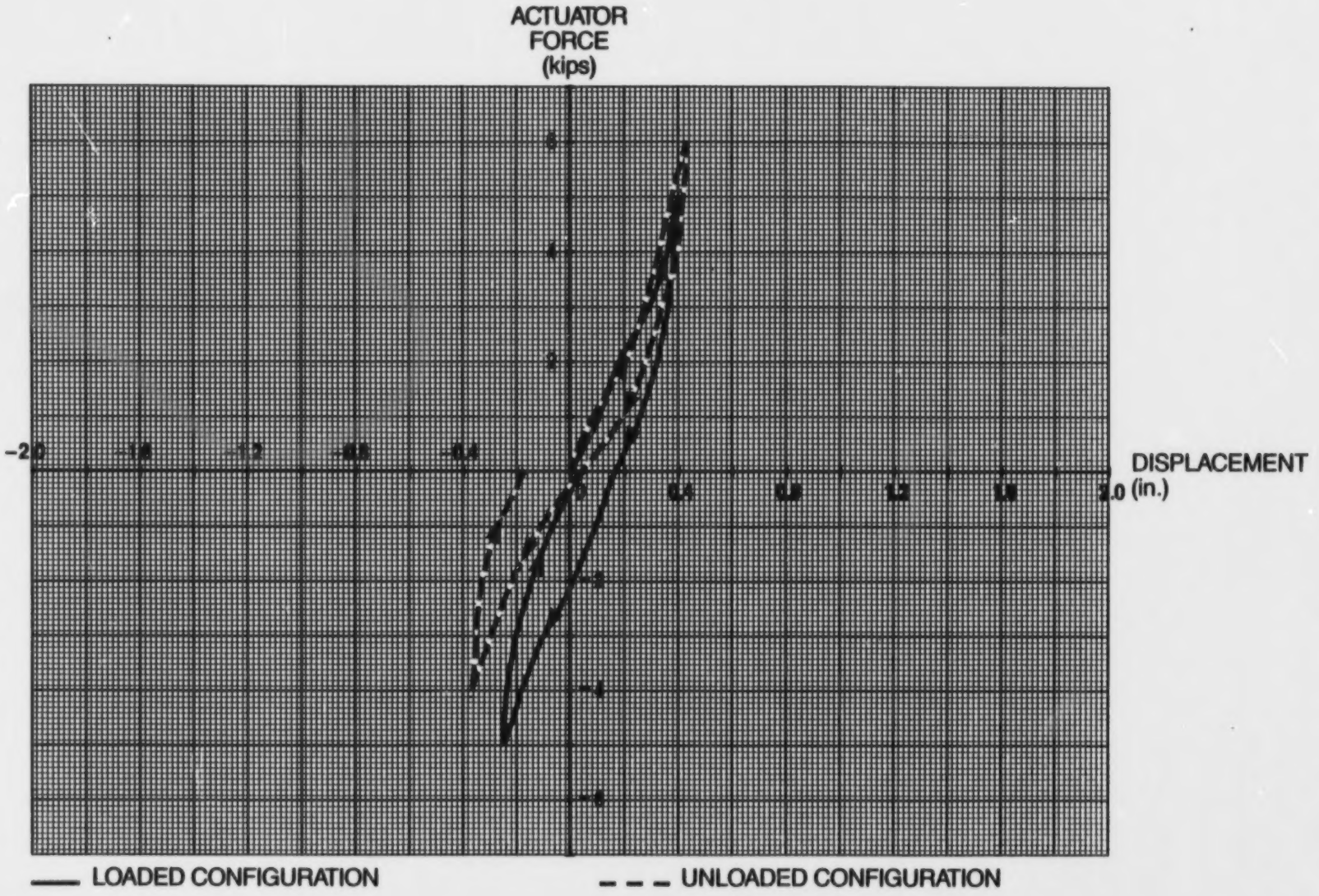


Fig. 5: INTERAXLE SHEAR DISPLACEMENT vs. ACTUATOR FORCE FOR RIGIDIZED ELASTO-CUSHION TRUCK

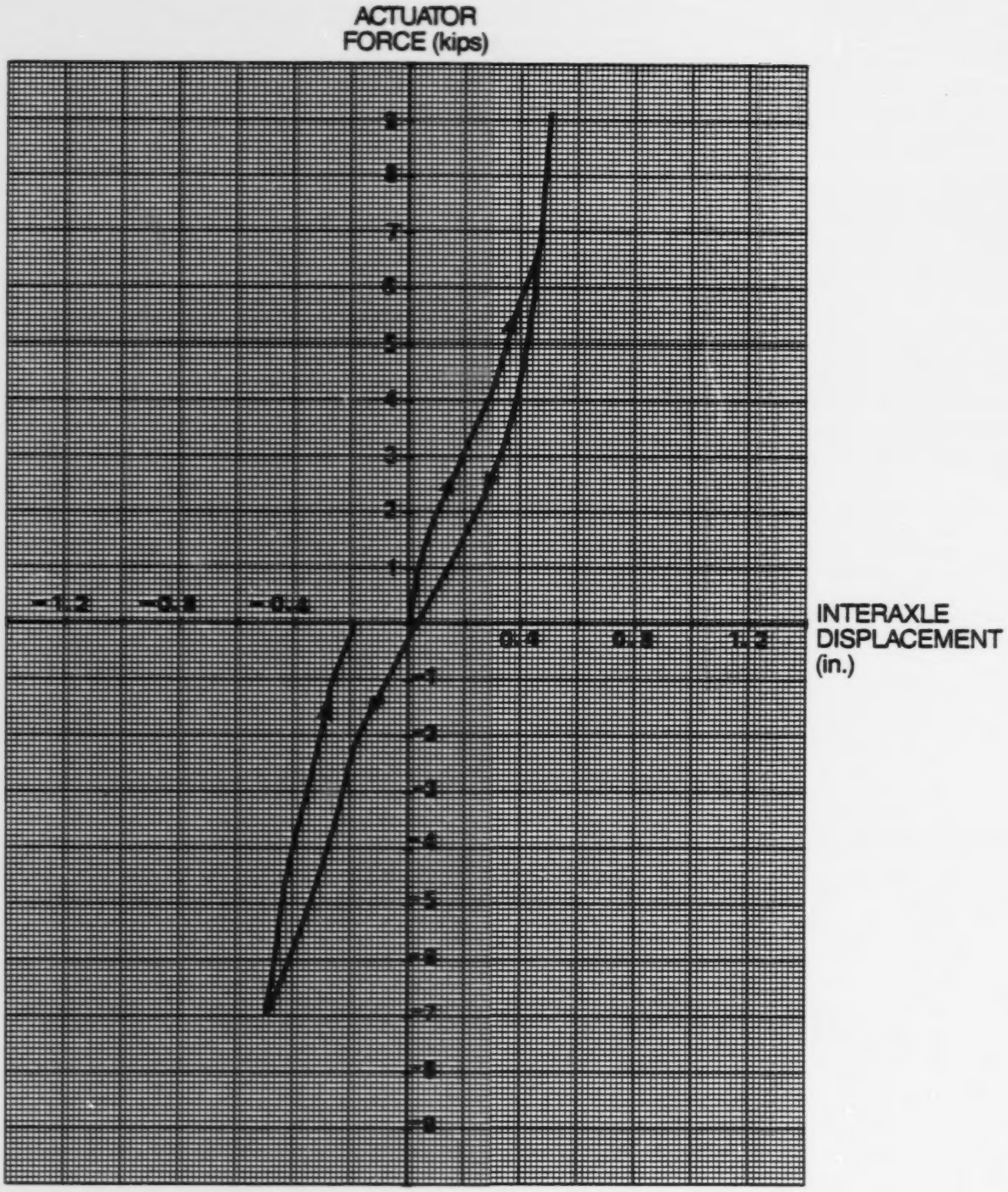


Fig. 6: INTERAXLE SHEAR DISPLACEMENT vs. ACTUATOR FORCE FOR RIGIDIZED ELASTO-CUSHION TRUCK WITHOUT FRICTION WEDGES

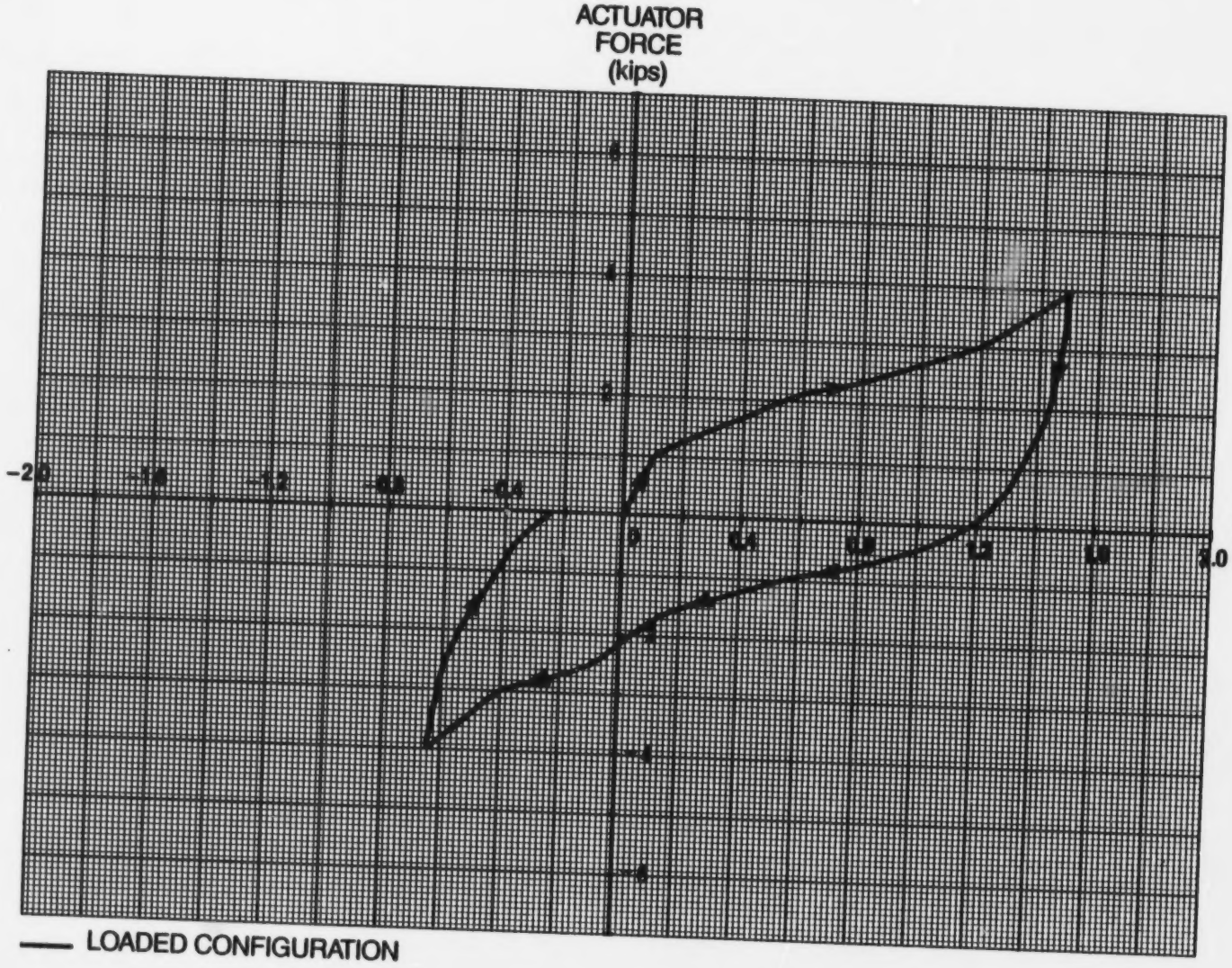


Fig. 7: INTERAXLE SHEAR DISPLACEMENT vs. ACTUATOR FORCE FOR CONVENTIONAL TRUCK WITH LC PADS

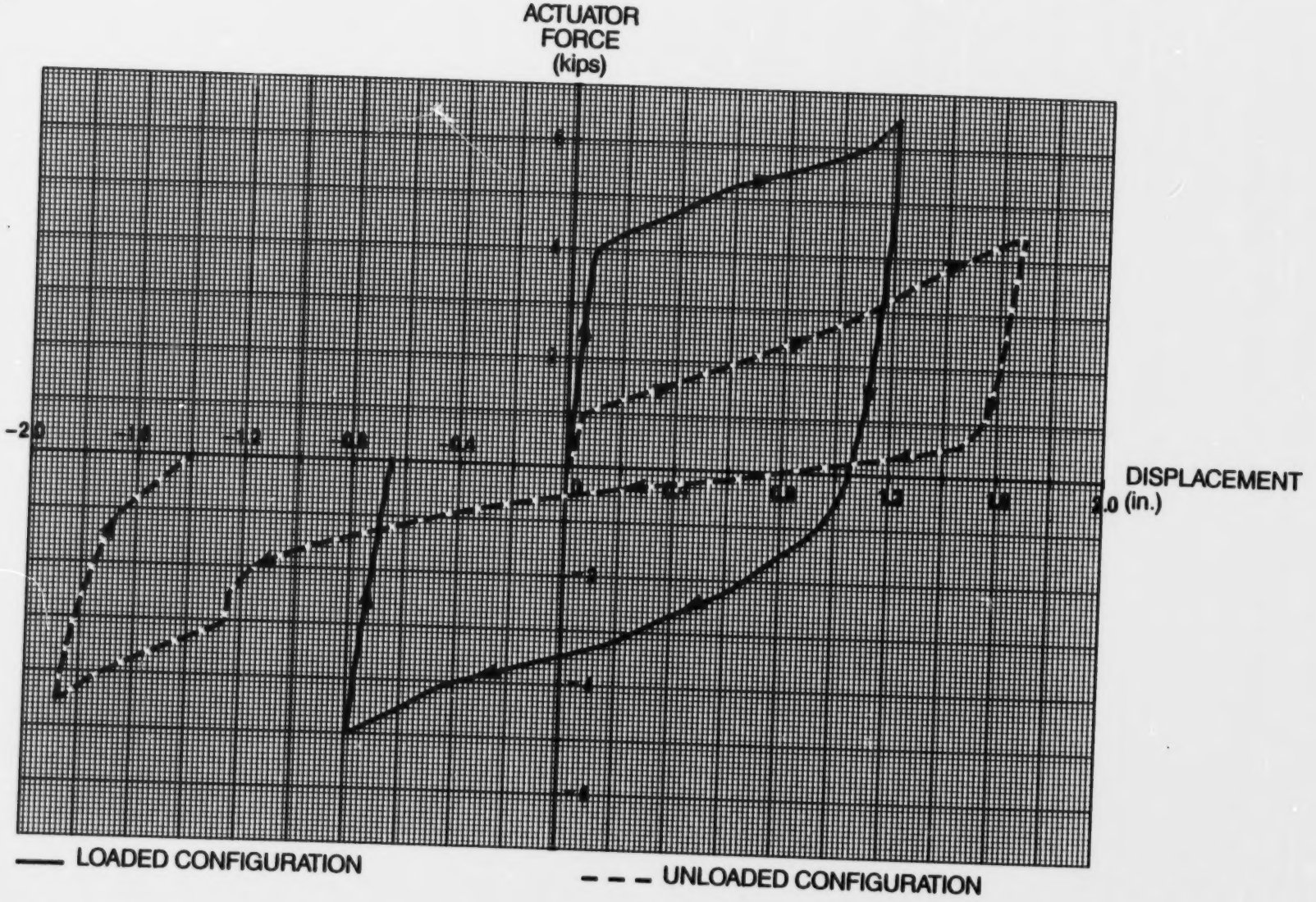


Fig. 8: INTERAXLE SHEAR DISPLACEMENT vs. ACTUATOR FORCE FOR CONVENTIONAL TRUCK

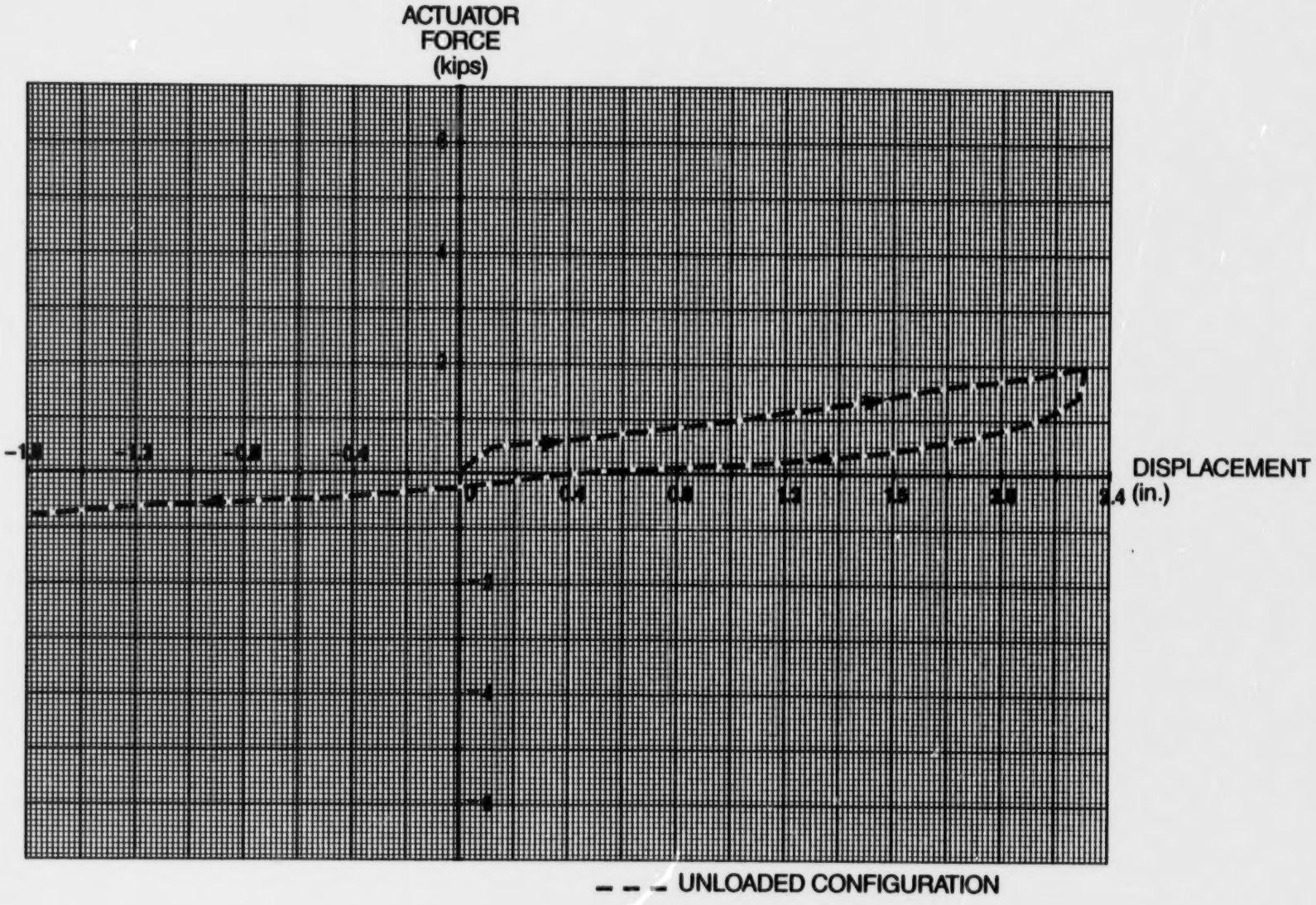


Fig. 9: INTERAXLE SHEAR DISPLACEMENT vs. ACTUATOR FORCE FOR CONVENTIONAL TRUCK WITHOUT WEDGES

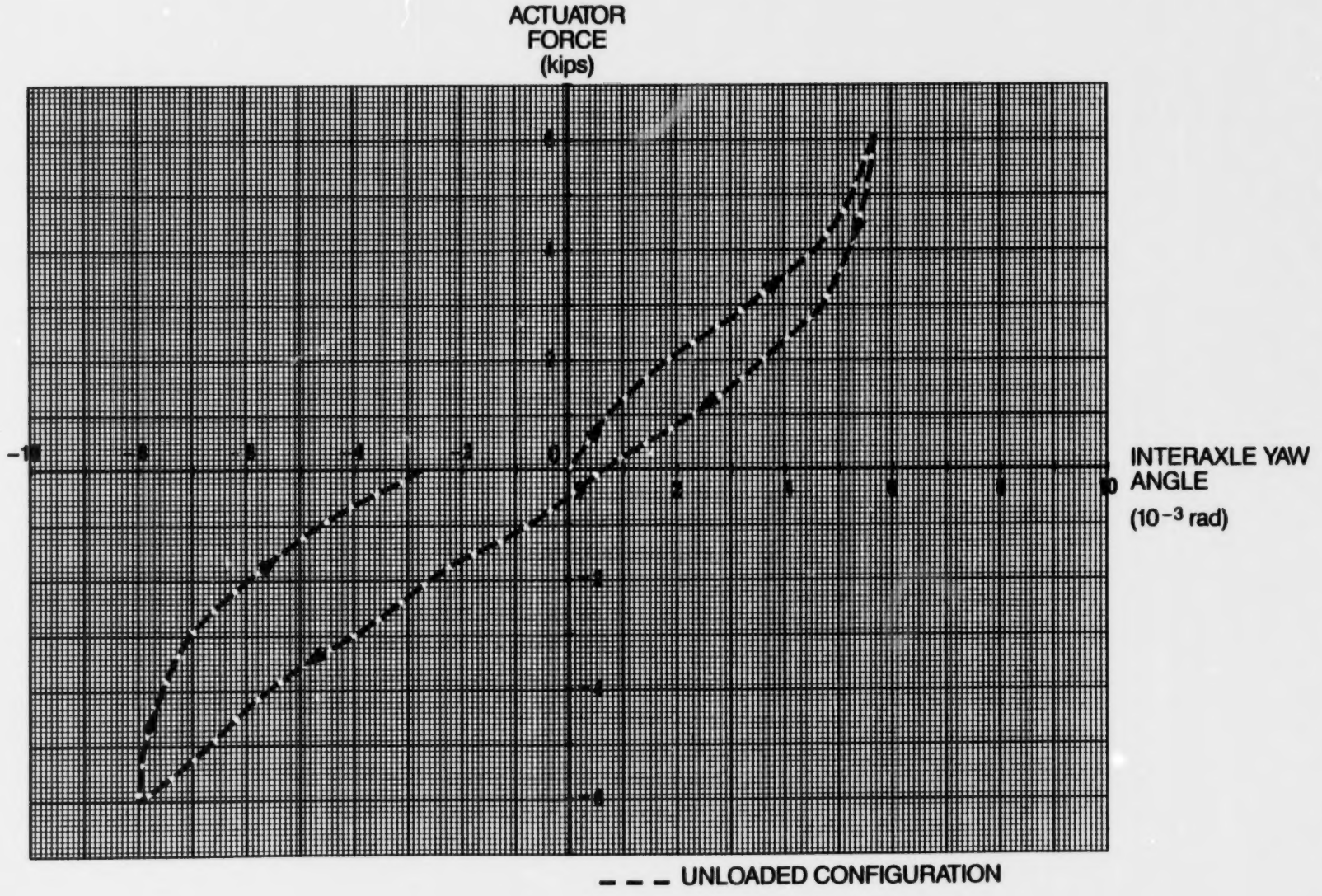


Fig. 10: INTERAXLE YAW ANGLE vs. ACTUATOR FORCE FOR RIGIDIZED ELASTO-CUSHION TRUCK

RIGIDIZED ELASTO-CUSHION TRUCK

STABILITY TEST

R.F. Gonsalves
Research and Development Dept.
Report No. T-925-86
June, 1986.

SUMMARY

A series of tests was carried out with rigidized elasto-cushion trucks on the Montreal and Ottawa Subdivision near Rigaud to determine the stability performance of the test trucks. The rigidized elasto-cushion trucks with severely worn wheels were tested on a light flat car CP 303430 over a one mile section of tangent track, in 5 mph speed increments from 40 mph to 65 mph. On completion of the stability tests the rigidized elasto-cushion trucks were restored to "conventional" trucks and the tests repeated to obtain base data for comparison.

Rigidized elasto-cushion trucks with severely worn wheels under a car of relatively light weight of 54,000 lbs. were stable to a test speed of 60 mph. At 65 mph the trucks hunted intermittently. Rigidized elasto-cushion trucks restored to convential trucks hunted intermittently at 45 mph and hunted continuously above 50 mph. Carbody lateral acceleration levels were considerably reduced with rigidized elasto-cushion trucks when compared to conventional trucks.

SOMMAIRE

Des essais de stabilité ont été effectués sur des bogies "elasto-cushion" rigidifiés sur la ligne Ottawa-Montréal, près de Rigaud. Les bogie montés sur des roues très usées en service et portant un wagon plat CP 303430, ont été mis à l'essai sur un tronçon droit de 1 mille de long, à une vitesse initiale de 40 mi/h augmentée par tranches de 5 mi/h jusqu'à 65 mi/h. À la fin des essais, les bogies "elasto-cushion" rigidifiés ont été reconvertis en bogies "classiques" et les mêmes essais ont été refaits pour obtenir des données comparatives de base.

Les bogies "elasto-cushion" rigidifiés équipés de roues très usées en service et portant des wagons relativement légers de 54 000 lb sont demeurés stables jusqu'à 60 mi/h. À 65 mi/h, ils ont manifesté un lacet intermittent, alors que les bogies classiques avaient manifesté un lacet intermittent dès 45 mi/h et un lacet continu au-dessus de 50 mi/h. Comparativement aux bogies classiques, les bogies "elasto-cushion" rigidifiés ont induit des niveaux d'accélération latérale de la plate-forme considérablement réduits.

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1.0 Introduction

A series of stability tests was conducted near Rigaud in April 1986 to study the behaviour of conventional 70-ton trucks rigidized by means of a shear plate between the truck side frames to prevent parallelogramming (Figure 1). The test trucks referred to as rigidized elasto-cusion trucks were equipped with 25,000 lb./in. shear pads between the bearing adapter and side frame.

Previous tests conducted at Calgary showed that the rigidized elasto-cushion trucks had good stability characteristics in comparison to conventional trucks. However, in the earlier test, severely worn wheels were not used and the car on which the rigidized elasto-cushion trucks was evaluated was a relatively heavy gondola car with a tare weight of 69,000 lbs. It was decided to retest the rigidized elasto-cushion truck for stability under conditions of severely worn

service wheels (Figure 2) on a relatively light empty flat car CP 303430 with a tare weight of 54,000 lbs.

2.0 Test Site

Stability tests at speeds to 65 mph were carried out on the Montreal/Ottawa Subdivision near Rigaud, over a one mile section of tangent track consisting of 39' rail with staggered rail joints.

3.0 Instrumentation

Two accelerometers were mounted laterally, one on each trailing axle of each test truck. In addition, one accelerometer was mounted in the lateral direction on the car body bolster of the leading truck. Acceleration signal data were recorded on a 14 Ch F.M. tape recorder.

4.0 Test Procedure

The test procedure consisted of running the test car, in a captive consist, in 5 mph increments from 40 to 65 mph. Tests were all run in the

same direction with the required speed being attained prior to the start of the one mile test zone. The speed in the one mile test zone was held constant to record the lateral acceleration signal data.

On completion of the stability tests on the rigidized elasto-cushion trucks, the shear plates and elastomeric shear pads were removed from both trucks restoring them to "conventional" trucks. The conventional trucks were retested to obtain base data for comparison with that for the rigidized elasto-cushion trucks.

5.0 Data Analysis

A power spectral density (psd) analysis of the data was carried out to assess stability. For each test run, the lateral acceleration signal was analyzed over the entire one mile test zone. From the psd analysis the average lateral acceleration or the root mean square 'g' (rms 'g') level for the frequency range of 1 to 4Hz was calculated for each run so as to include the hunting frequency and avoid frequencies unrelated to wheelset lateral oscillation.

6.0 Dicussion of Test Results

Figures 3 to 5 illustrate the output of the power spectral density analysis in the form of signal power against frequency in units of g^2/Hz ($g=32.2$ ft./sec^2) for the rigidized elasto-cushion trucks and carbody and that of conventional trucks. As can be observed from the plots, when truck or car body hunting occurred the predominant response remained relatively constant at 2.6 to 2.8Hz but the amplitude increased with increasing test speed.

The conventional trucks commenced hunting intermittently at 45 mph and hunted continuously at 50 mph whereas the rigidized elasto-cushion trucks were stable to 60 mph. At 65 mph the rigidized elasto-cushion trucks hunted intermittently.

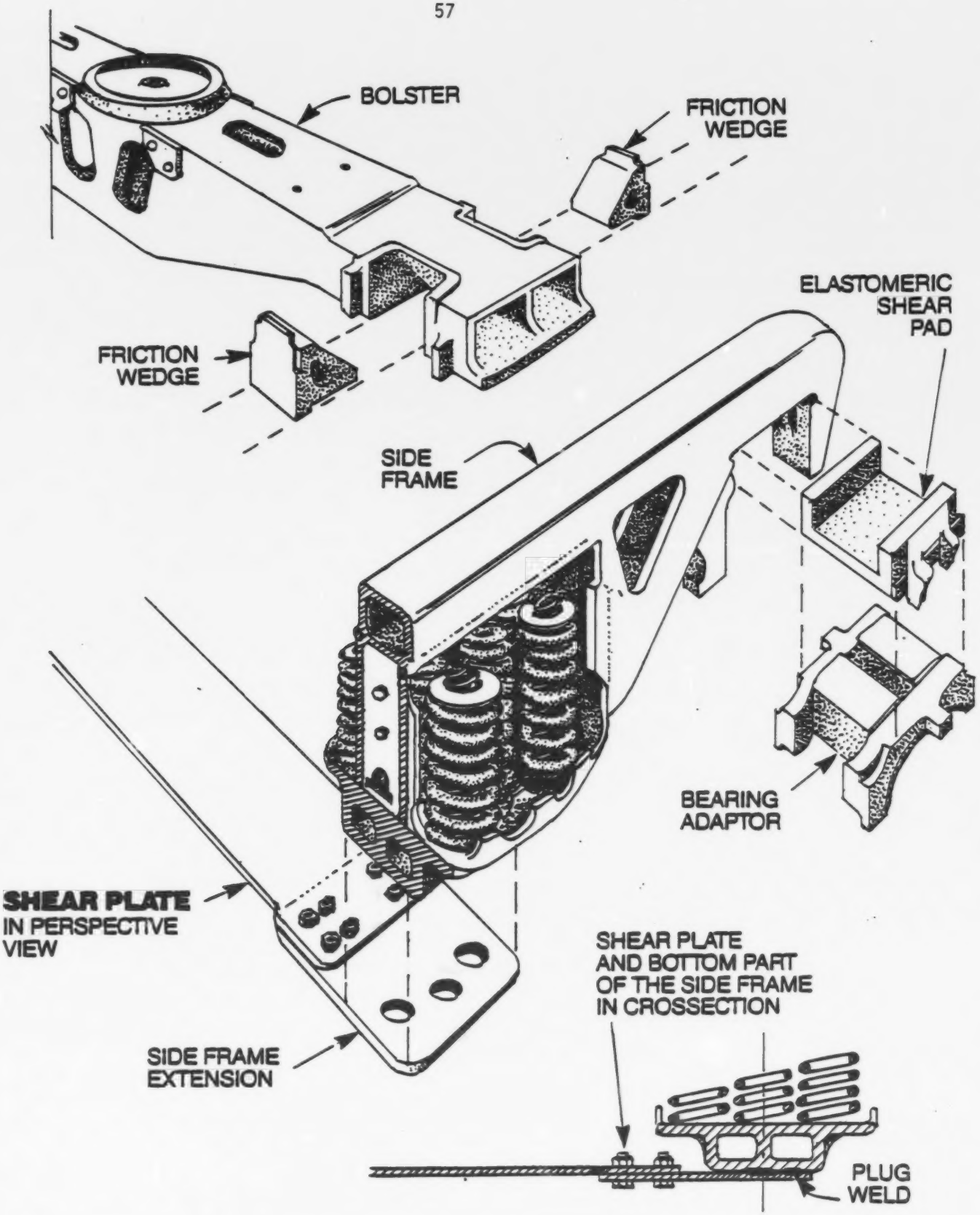
The r.m.s. 'g' values obtained from the psd analysis were plotted against each test speed for the trucks in Fig. 6 and the carbody in Fig. 7 Both, truck and carbody lateral acceleration were lower with the rigidized elasto-cushion trucks.

7.0 Test Results

1. Rigidized elasto-cushion trucks with severely worn service wheels under a car of relatively low tare weight of 54,000 lbs. were stable to a test speed of 60 mph. At 65 mph. the trucks hunted intermittently.

2. Rigidized elasto-cushion trucks restored to conventional trucks, hunted intermittently at 45 mph and continuously at 50 mph and above.

3. Carbody lateral acceleration levels were considerably reduced with rigidized elasto-cushion trucks compared to conventional trucks.



RIGIDIZED ELASTO CUSHION TRUCK

Figure: 1

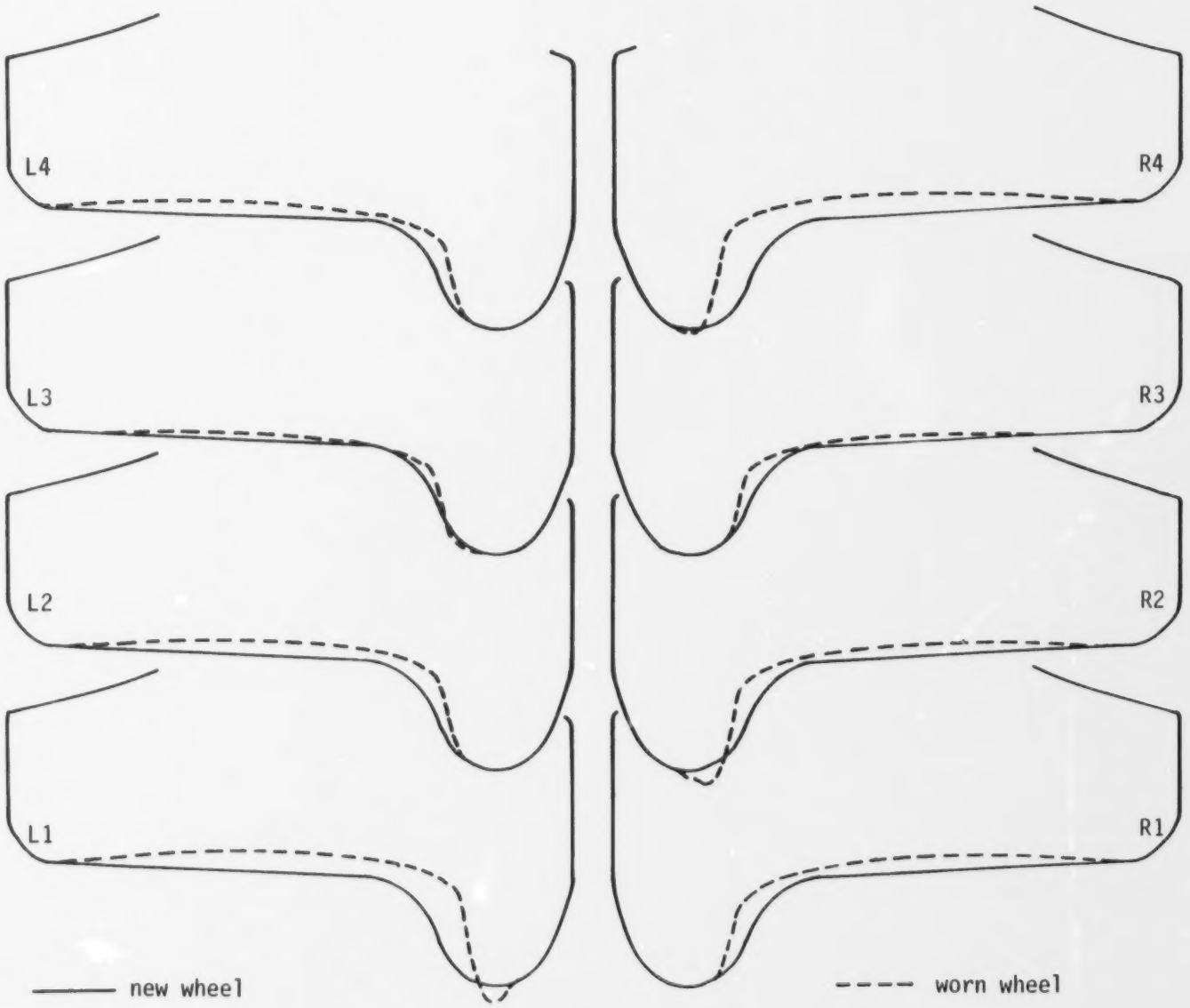
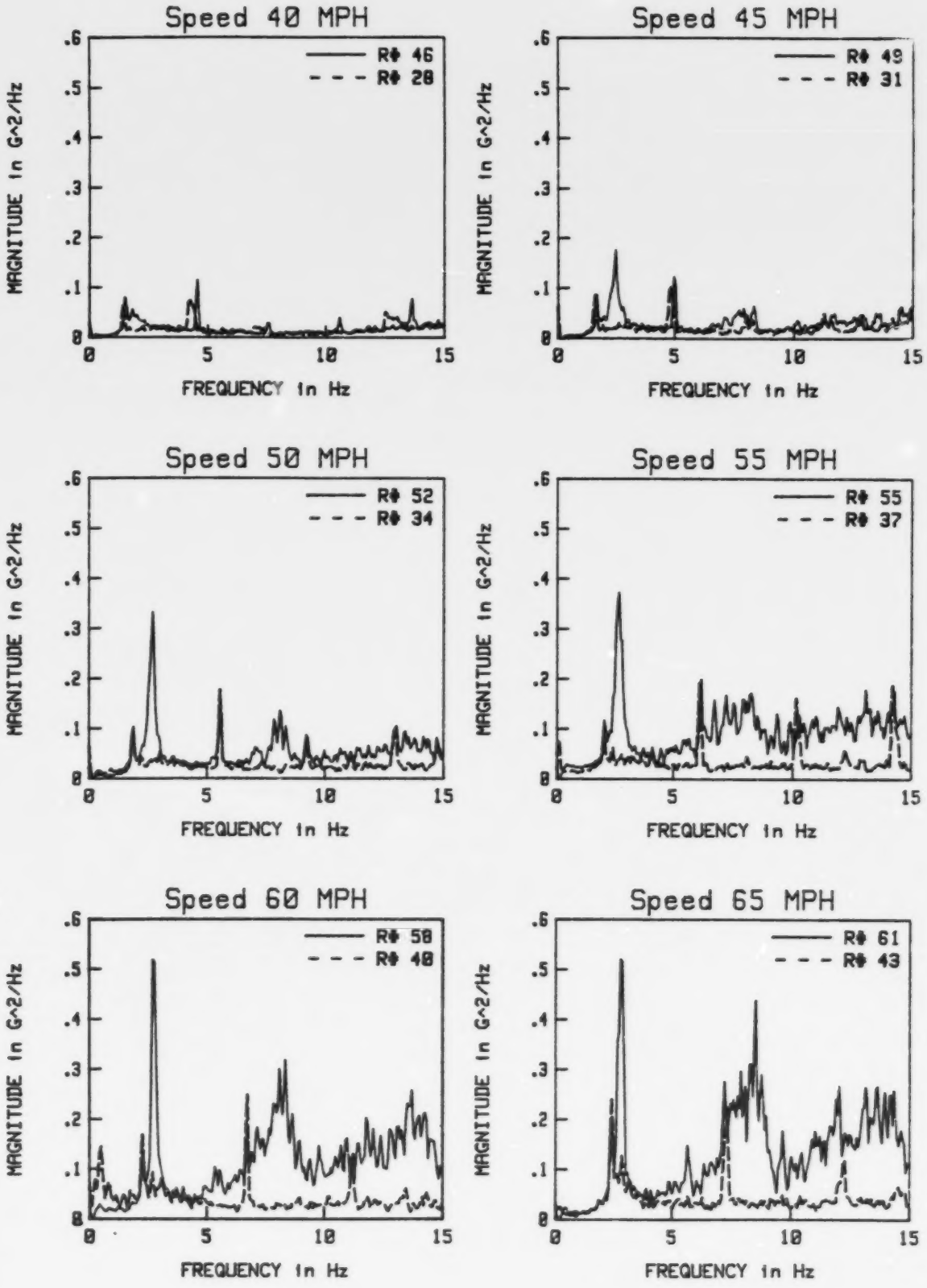
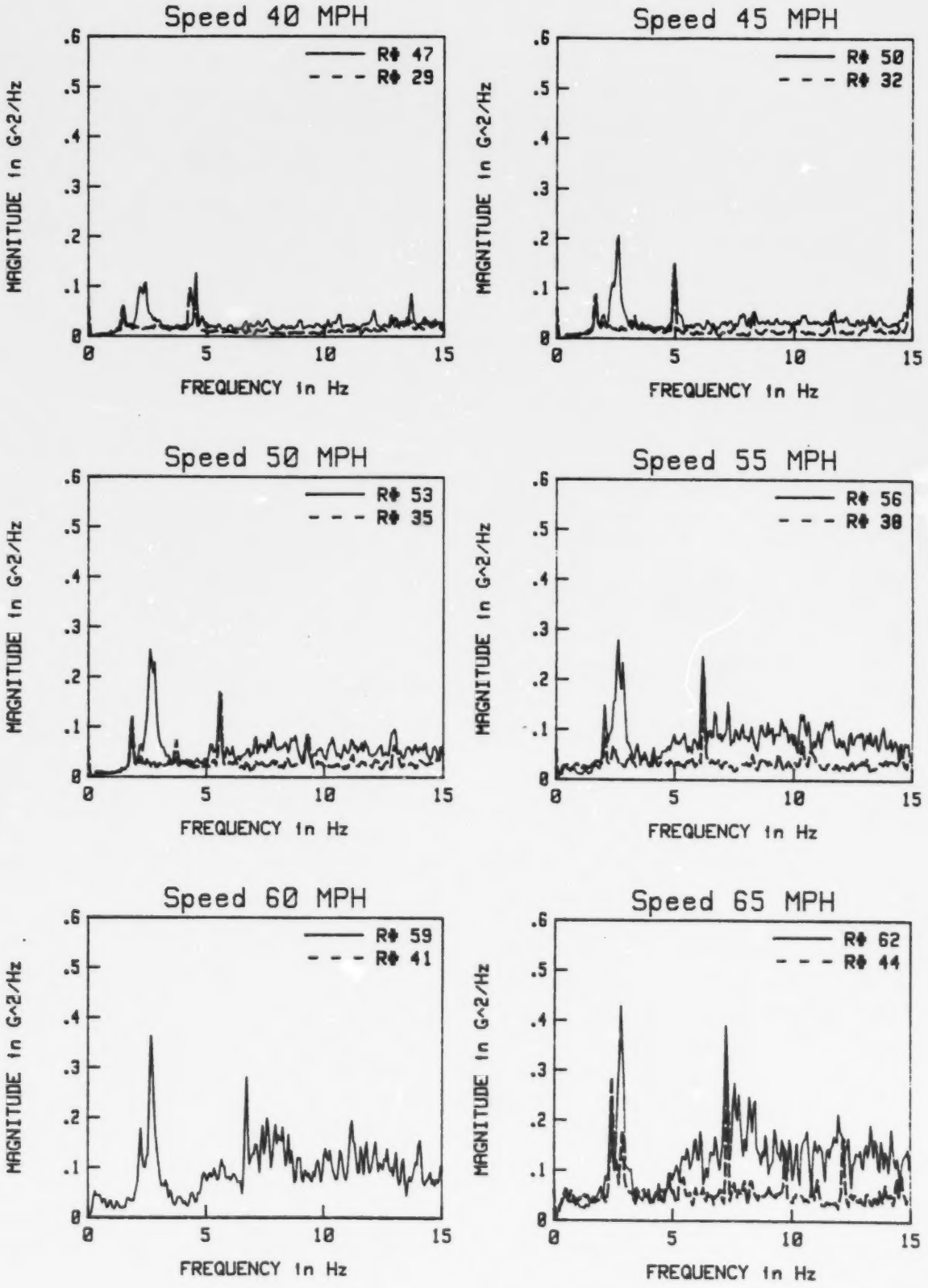


Figure 2 : WHEEL PROFILES OF CAR CP 303430



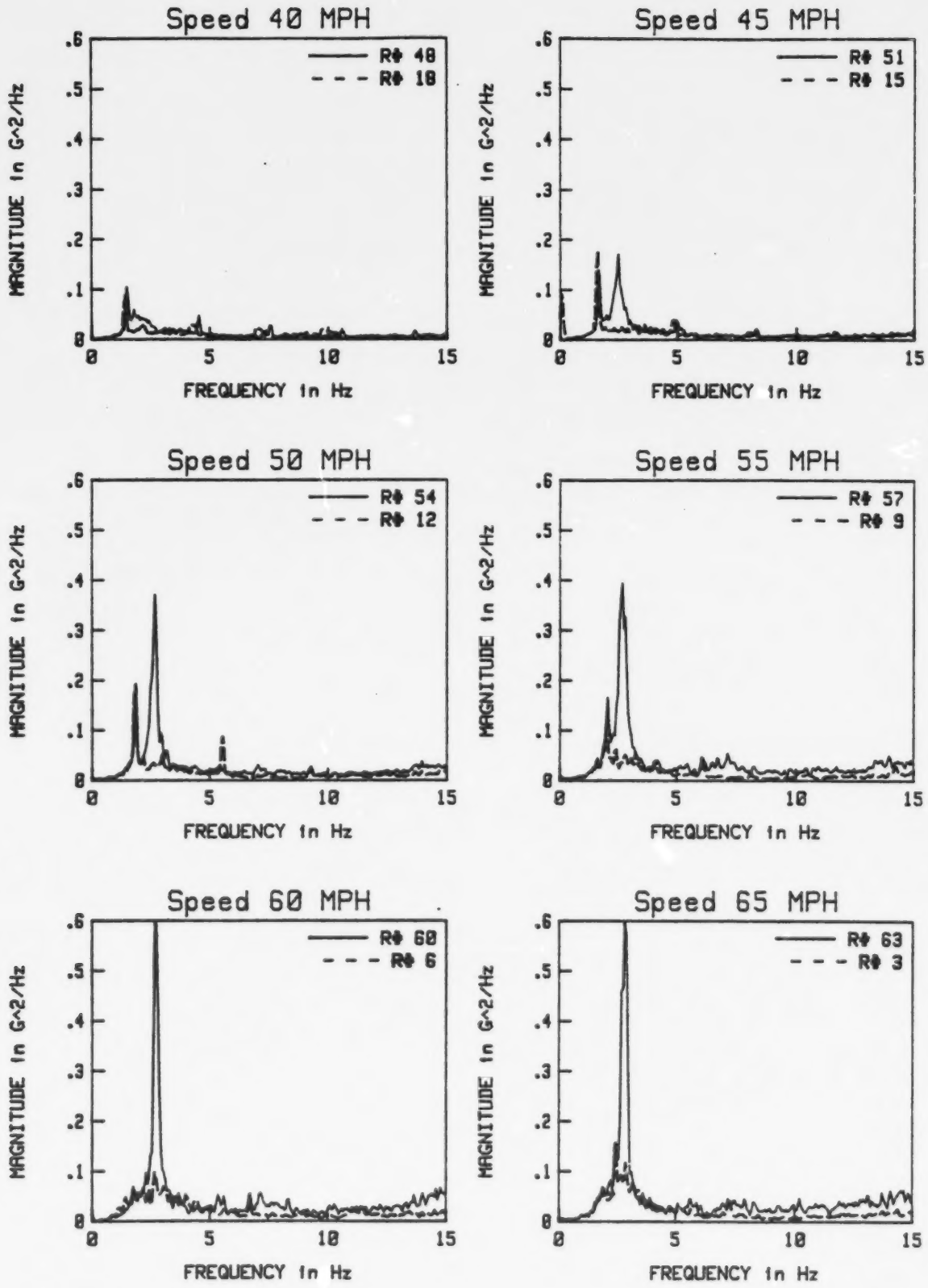
REF & RIGID(dash) 70 TON LEADING TRUCKS

FIGURE 3



REF & RIGID(dash) 70 TON TRAILING TRUCKS

FIGURE 4



REF & RIGID(dsah) 70 TON LEADING BODY

FIGURE 5

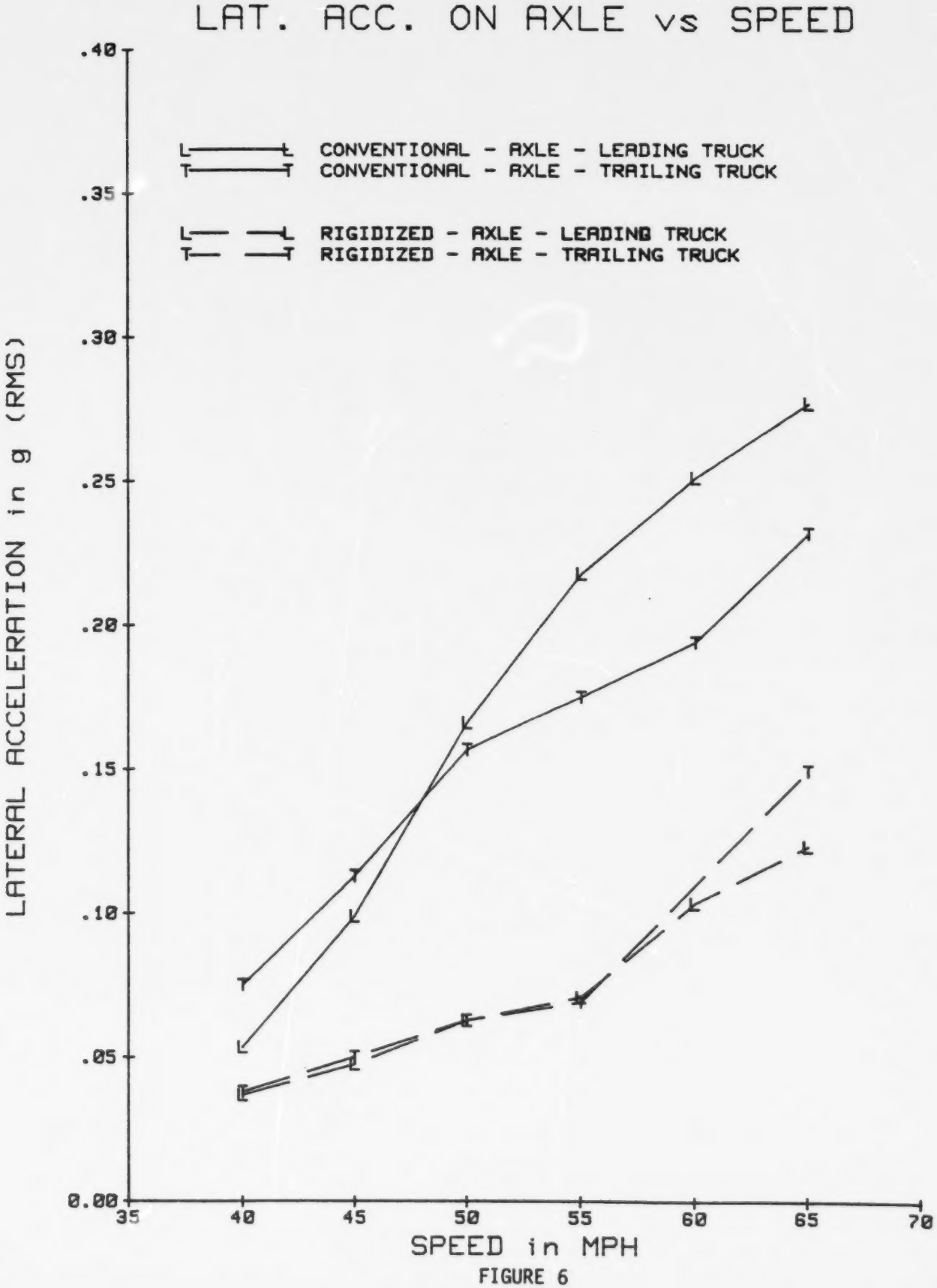

LAT. ACC. ON AXLE vs SPEED
CONVENTIONAL - AXLE - LEADING TRUCK
CONVENTIONAL - AXLE - TRAILING TRUCK
RIGIDIZED - AXLE - LEADING TRUCK
RIGIDIZED - AXLE - TRAILING TRUCK
LATERAL ACCELERATION in g (RMS)
.40
.35
.30
.25
.20
.15
.10
.05
0.00
35
40
45
50
55
60
65
70
SPEED in MPH

FIGURE 6

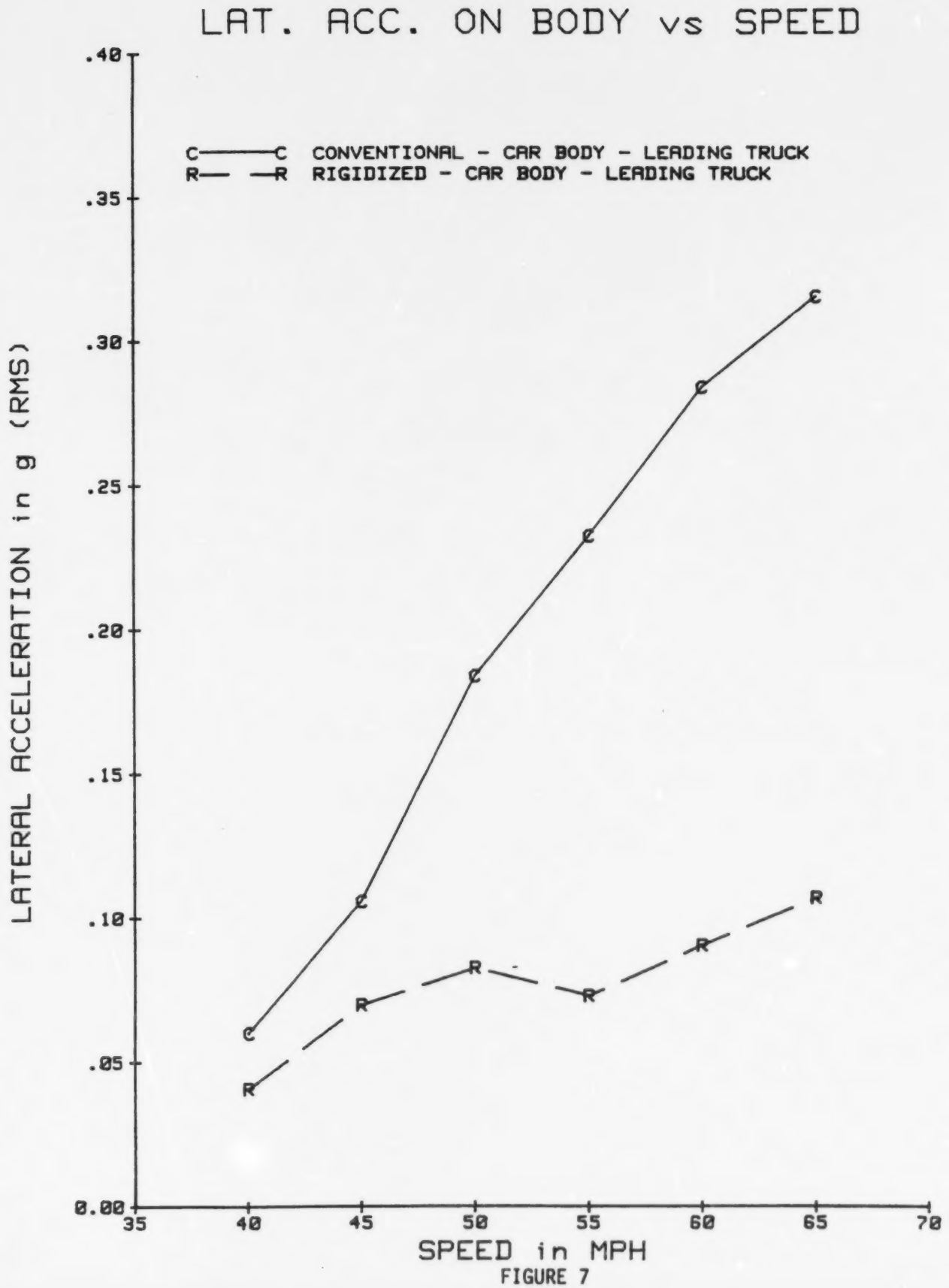

LAT. ACC. ON BODY vs SPEED
C——C CONVENTIONAL - CAR BODY - LEADING TRUCK
R— —R RIGIDIZED - CAR BODY - LEADING TRUCK
LATERAL ACCELERATION in g (RMS)
.40
.35
.30
.25
.20
.15
.10
.05
0.00
35
40
45
50
55
60
65
70
SPEED in MPH

FIGURE 7

STABILITY TEST EVALUATION OF CP 100-TON BATHTUB COAL CAR WITH UTDC FRAME-BRACED TRUCKS

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SUMMARY

A series of high speed stability tests was conducted to 70 mph on a CP 100-ton bathtub coal car equipped with UTDC frame braced trucks having 25,000 lbs/in shear pads and service worn wheels.

The results indicate that hunting persists above 50 mph with this truck configuration when service worn wheels are applied. The lead truck was less stable and hunted continuously above 50 mph, with increasing severity to 65 mph. Trailing truck hunting was intermittent above 55 mph, and continuous at 65 mph.

Re-testing the same trucks with the frame braces and shear pads removed and new C-PEP's added showed that the lateral instability of the lead truck became less severe from a low operating speed up to about 60 mph.

Above 60 mph the leading truck of both UTDC frame braced and converted conventional configurations hunted continuously with similar magnitudes of lateral accelerations.

SOMMAIRE

Une série d'essais de stabilité à grande vitesse, soit 70 mi/h, a été réalisée avec un wagon à charbon de 100 tonnes monté sur des bogies à liaison croisée des longerons équipés de blocs en caoutchouc d'une raideur de cisaillement de 25 000 lb/po et de roues à usure caractéristique en service.

Avec ce type de montage, les résultats indiquent un lacet persistant au-dessus de 50 mi/h. Le bogie avant était moins stable et manifestait un lacet continu au-dessus de 50 mi/h, le phénomène s'aggravant jusqu'à 65 mi/h. Le bogie arrière manifestait un lacet intermittent au-dessus de 55 mi/h et continu à 65 mi/h.

Les mêmes essais effectués sur des bogies dont la liaison croisée des longerons et les blocs en caoutchouc avaient été enlevés et remplacés par de nouveaux blocs C-PEP ont permis de constater que l'instabilité latérale du bogie avant devenait moins importante à faible vitesse et jusqu'à environ 60 mi/h.

Au-dessus de 60 mi/h, les deux types de bogie testés ont tous deux manifesté, en position avant, un lacet continu d'accélérations latérales de même ordre de grandeur.

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1.0 INTRODUCTION

The Research and Development Department of CP Rail carried out a series of high speed stability tests on a 100-ton bathtub coal car, CP 352258, equipped with UTDC frame braced trucks. These field tests were conducted during September 1985 near Calgary.

2.0 UTDC FRAME BRACED TRUCK TEST BACKGROUND

The UTDC frame bracing hardware is a retrofit package for the conventional Barber S2-C three-piece truck. The truck side frames are held rigid by the addition of diagonal frame bracing. These diagonal braces between the two side frames are resiliently mounted in brackets welded to the sideframes. Elastomeric shear pads located at the side frame pedestal roof and bearing adaptors provide shear elasticity for wheelset steering.

Previous stability tests conducted on these same UTDC frame braced trucks, in the fall of 1984, with shear pads of 15,000 lb/in stiffness indicated that the less stable truck of the test car developed lateral instability starting at 50 mph with the worst axle acceleration reaching approximately 0.28 'g' rms at 65 mph. Subsequently, it was decided by CP Rail and UTDC to retest these trucks with stiffer pads.

This report documents the stability test procedures and findings of this retest with UTDC trucks having 25,000 lb/in stiffness shear pads over the same test section where previous tests were conducted.

3.0 STABILITY TESTS

3.1 Test Site and Test Consist

The tests were carried out on CWR tangent track between MP 160 and MP 158 on the Brooks Subdivision, east of Calgary. The test consist was as follows:

Unit 6052	SD40-2 Locomotive
Unit 5879	SD40-2 Locomotive
NRC 1001	Instrument Car
CP 352369	100-ton bathtub coal car with other test trucks
CP 352258	100-ton bathtub coal car with UTDC cross-braced trucks

One crew caboose

3.2 Test Procedures and Instrumentation

Two series of stability tests were conducted with CP 352258 with UTDC trucks. During each test, the consist was operated over the test section at speeds ranging from 30 to 70 mph in 5 mph increments. On September 11, 1985, the UTDC frame braced trucks were tested with service worn wheels (Fig. 2). On September 12, 1985, the cross-braces and shear pads were removed, and C-PEP's installed at Ogden shop to change the UTDC trucks into conventional Barber S2-C truck configuration (Fig. 1). On September 13, 1985, a second series of stability tests was conducted over the same test section with these conventional trucks, using the same service worn wheels. In all tests, the "A" end of the test car was leading.

The lateral accelerations were recorded at the following car body and truck locations:

11/09/85 A.M.

Condition: UTDC Frame Braced Trucks

(A) "A" end axle No. 4
(B) "B" end axle No. 2 (Fig. 3)

11/09/85 P.M.

Condition: UTDC Frame Braced Trucks

(C) "A" end car body bolster
(D) "B" end car body bolster

13/09/85

Condition: Same Test Trucks With Cross-Braces and Shear Pads Removed, and C-PEP's Added (i.e. Conventional Truck Configuration)

(E) "A" end axle No. 3
(F) "A" end side frame at column, rear axle side
(G) "A" end car body bolster

3.3 Data Processing

All lateral accelerometer signals filtered at 100 Hz were recorded on FM tape and simultaneously displayed on strip chart during the tests (Figs. 4 to 7). Power Density Analyses (PSD) of the data were performed using an HP model 5420A digital signal analyzer at NRC. The resulting "PSD" plots are displayed in Appendix A.

From these PSD plots, the root mean square 'g' (rms 'g') value for the frequency range between 1 to 5 Hz was calculated for each test run and presented from Fig. 8 to Fig. 10 in graphical form versus test speeds.

3.4 Test Results

From Figures 8 to 9, it is evident that body lateral instability was caused by UTDC truck wheelset oscillation and this cyclic oscillation at both carbody and truck was continuous at the lead truck position starting from 50 mph, with increasing amplitude to 65 mph. At the trailing truck position ('B' end) the body exhibited intermittent hunting at 55 mph and this instability eventually became continuous by 65 mph.

During the second test series, when the frame braces and shear pads were removed, and new C-PEP's added, the hunting of the car body at the leading position ('A' end) was less severe, with continuous hunting occurring at 65 mph.

The rms 'g' graphs from Figure 8 to Figure 10 summarize these results. It can be seen that in each test, there was a close correspondence between the acceleration at carbody bolster and axle acceleration at the same end. This indiates that the body lateral oscillation was caused by truck oscillations due to lateral instability.

At 65 mph, both leading and trailing UTDC truck axle lateral accelerations recorded were approximately 0.22 'g' rms.

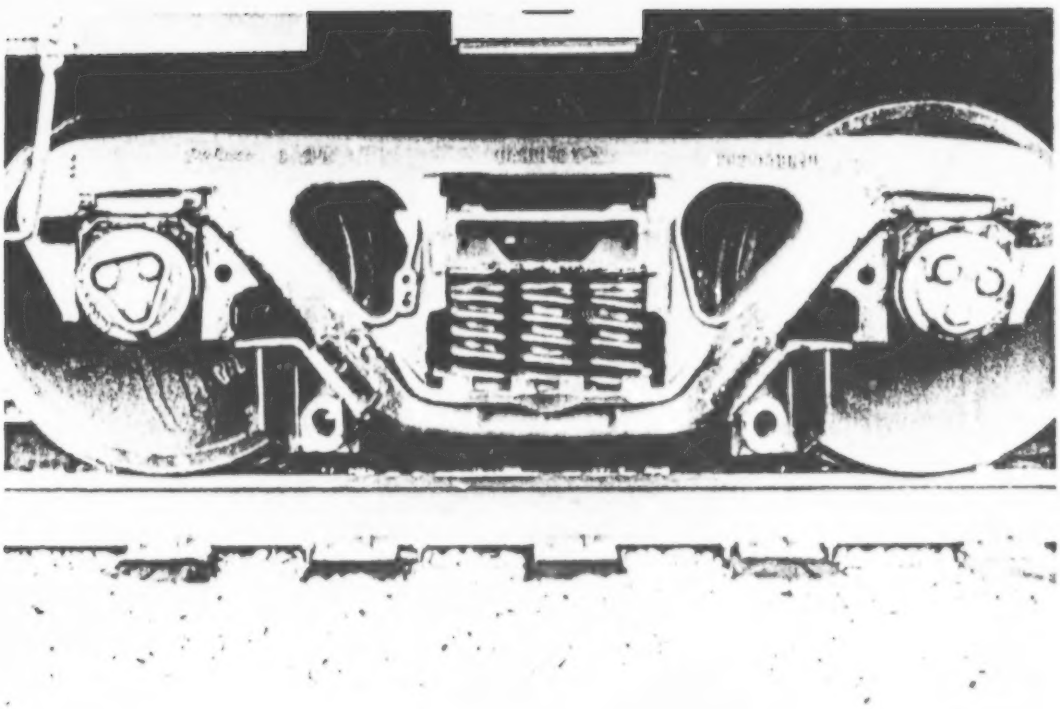
4.0 CONCLUSIONS

1. Improvement in hunting severity was observed with the UTDC frame braced trucks with 25,000 lbs/in shear pads compared with the same trucks tested with 15,000 lbs/in shear pads previously. However, the basic problem of lateral instability still persists above 50 mph even with the stiffer pads, when service worn wheels are applied.

2. Utilization of stiffer 30,000 lbs/in pads should improve the UTDC truck high speed stability performance. However, further field tests are still required to quantify whether this truck would be totally stable under 65 mph.

REFERENCES

1. R.F. Gonsalves, G. Izbinsky, D. D'Aoust: "UTDC Frame Braced, Rigidized Elasto-Cushion and Elasto-Cushion Truck Tests", Canadian Pacific Limited, Report No. T-864-85, May 1985.



UTDC TRUCK WITH SHEAR PADS, CROSS-BRACES REMOVED, AND C-PEP'S INSTALLED

Figure 1

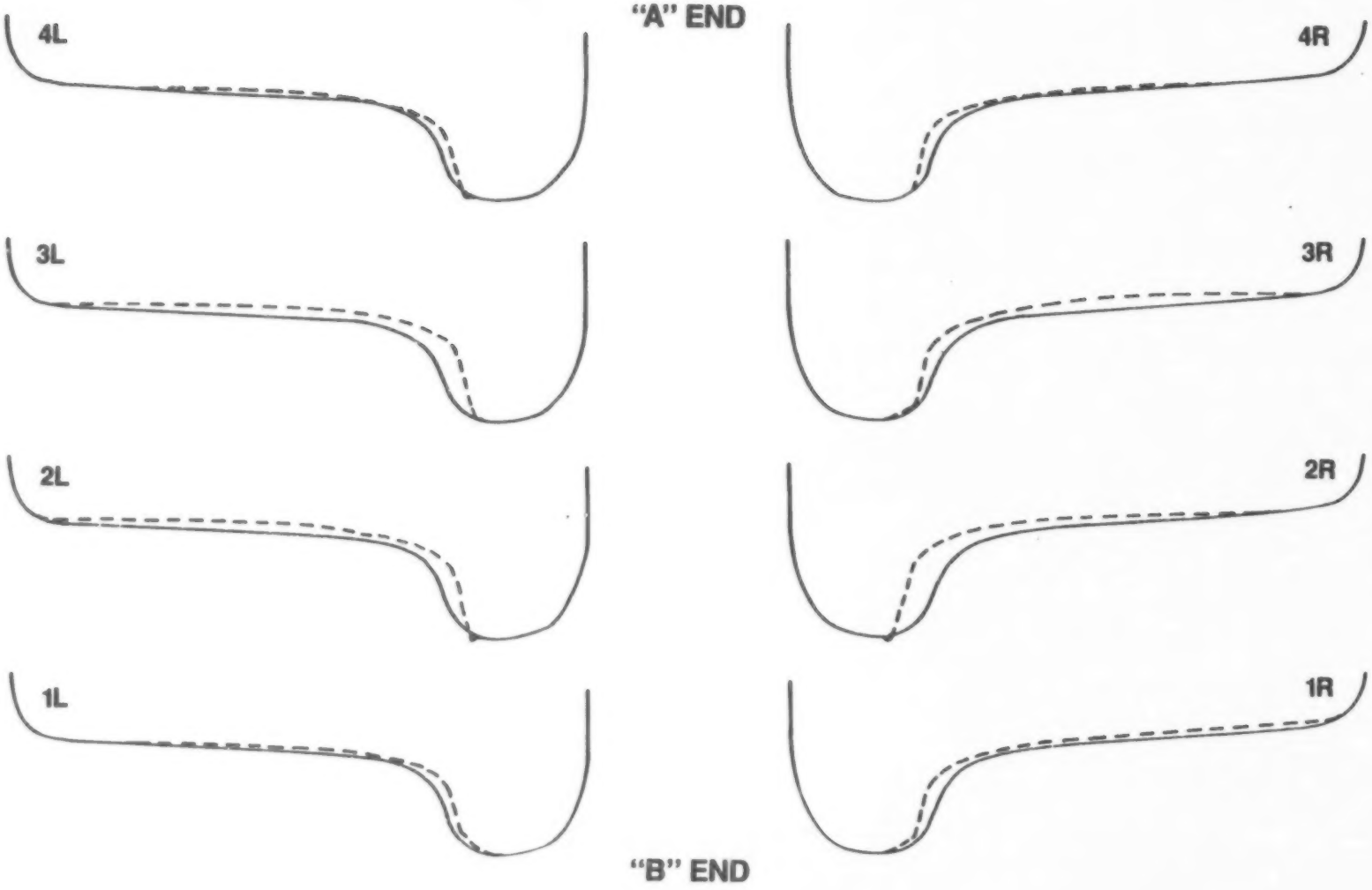
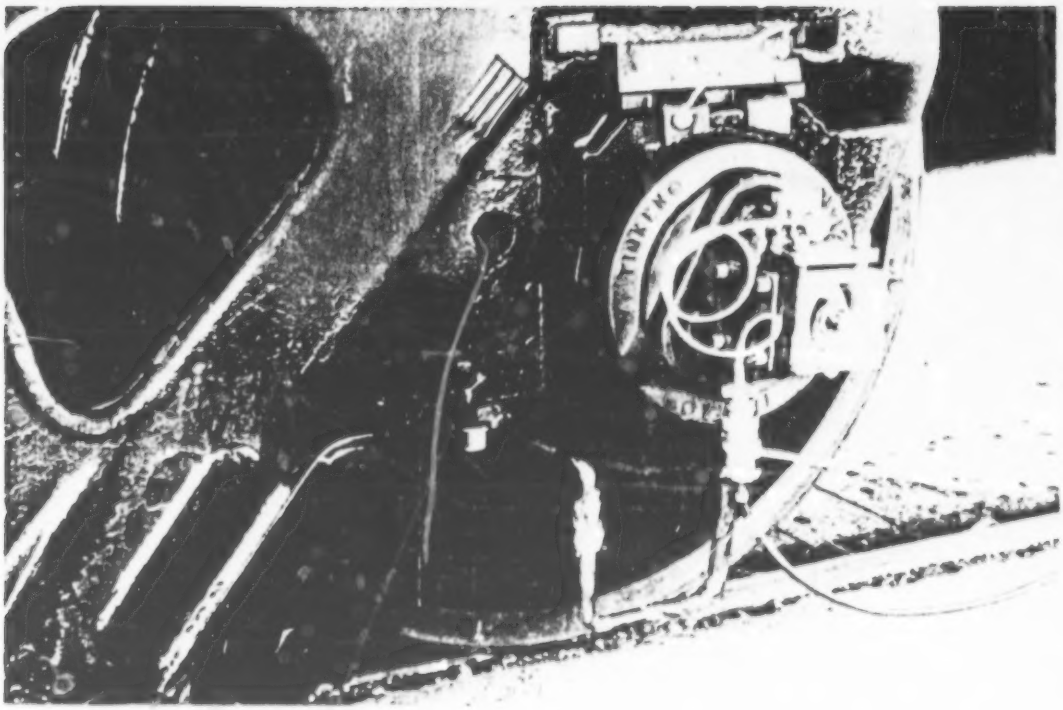
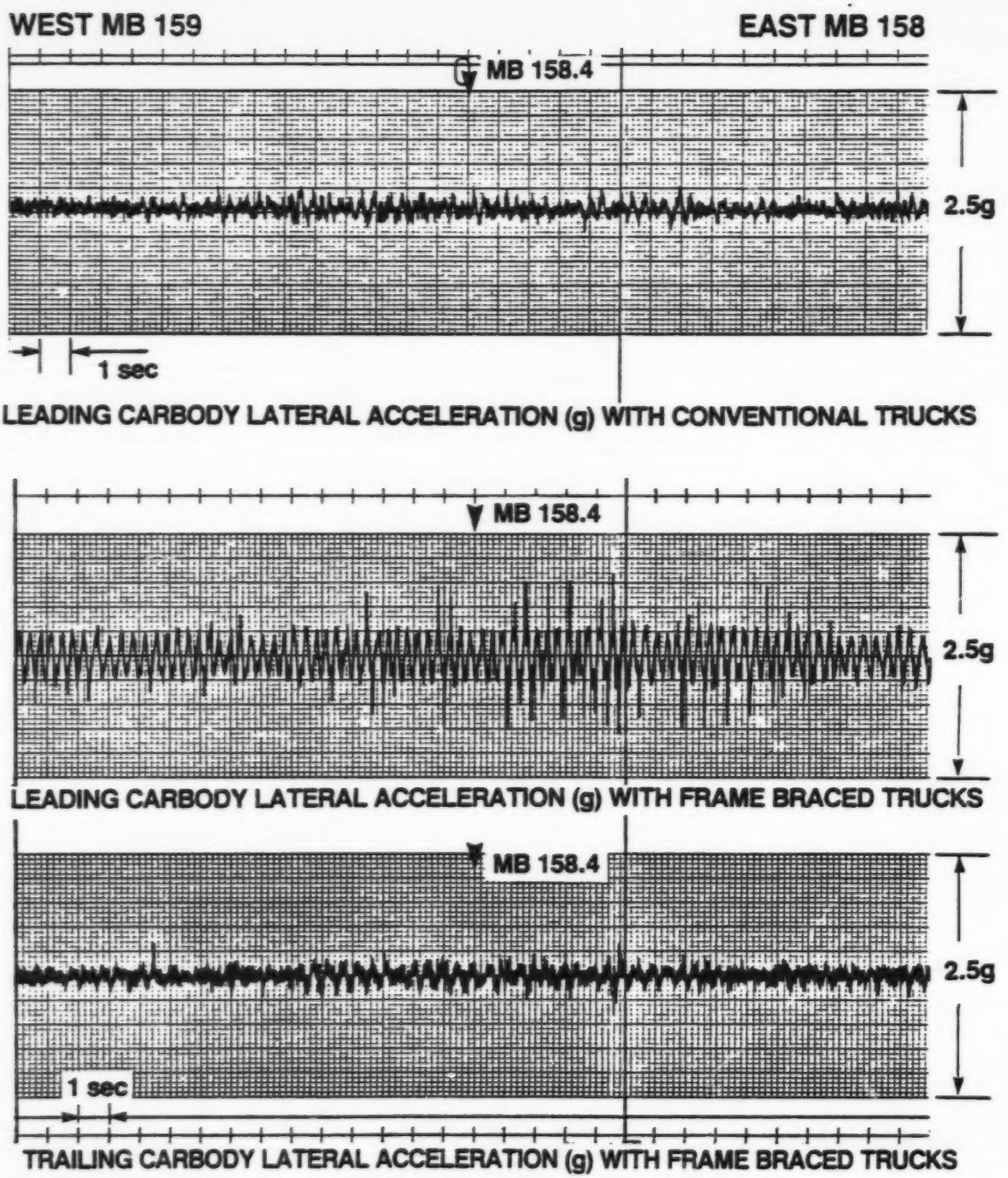


FIG. 2: WORN WHEEL PROFILES ON 100-TON BATHTUB COAL CAR CP 352258 WITH UTDC FRAME BRACED TRUCKS
_____ new wheel - - - - worn wheel



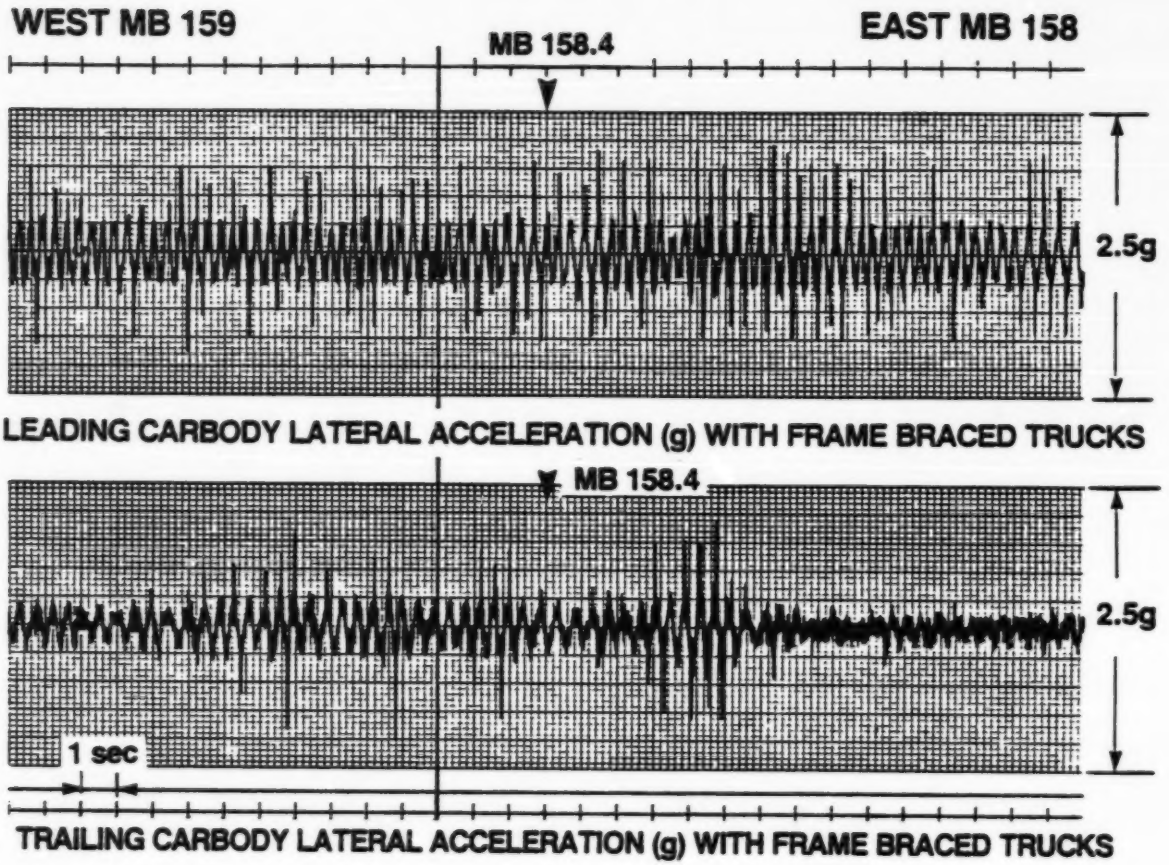
AXLE LATERAL ACCELEROMETER ON BEARING END CAP ON UTDC FRAME BRACED TRUCK

Figure 3



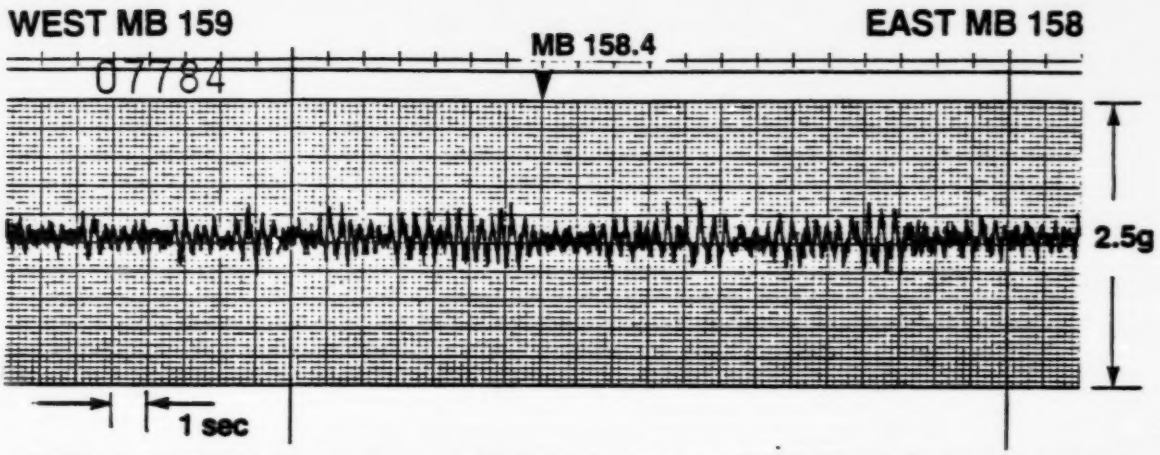
LATERAL BODY ACCELERATION OF COAL CAR CP 352258 WITH CONVENTIONAL AND UTDC FRAME BRACED TRUCKS RUNNING AT 50 mph BETWEEN MILE POST 159 AND 158 ON THE BROOKS SUBDIVISION

Figure 4

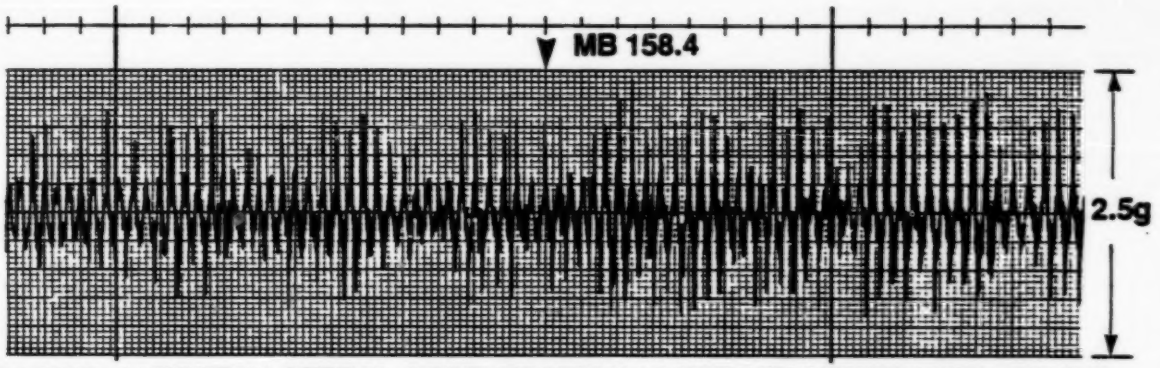


LATERAL BODY ACCELERATION OF COAL CAR CP 352258 WITH UTDC FRAME BRACED TRUCKS RUNNING AT 55 mph BETWEEN MILE POST 159 AND 158 ON THE BROOKS SUBDIVISION

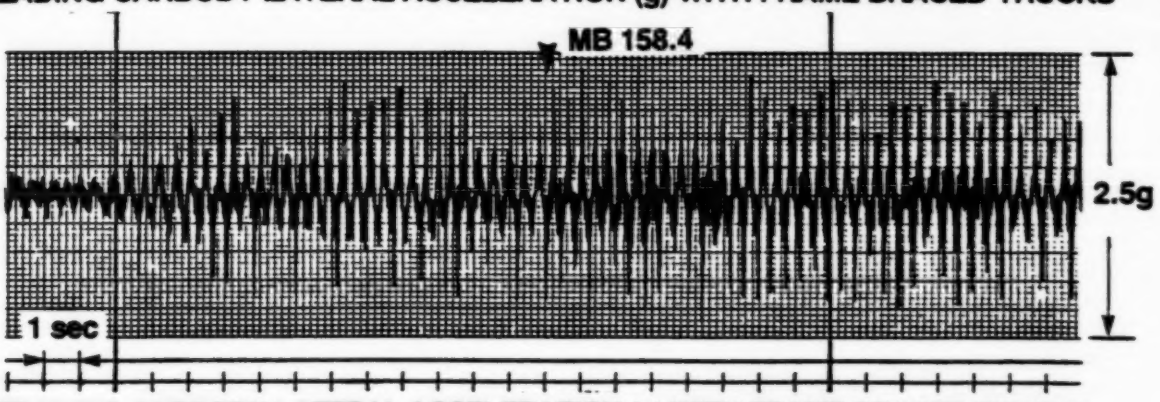
Figure 5



LEADING CARBODY LATERAL ACCELERATION (g) WITH CONVENTIONAL TRUCKS



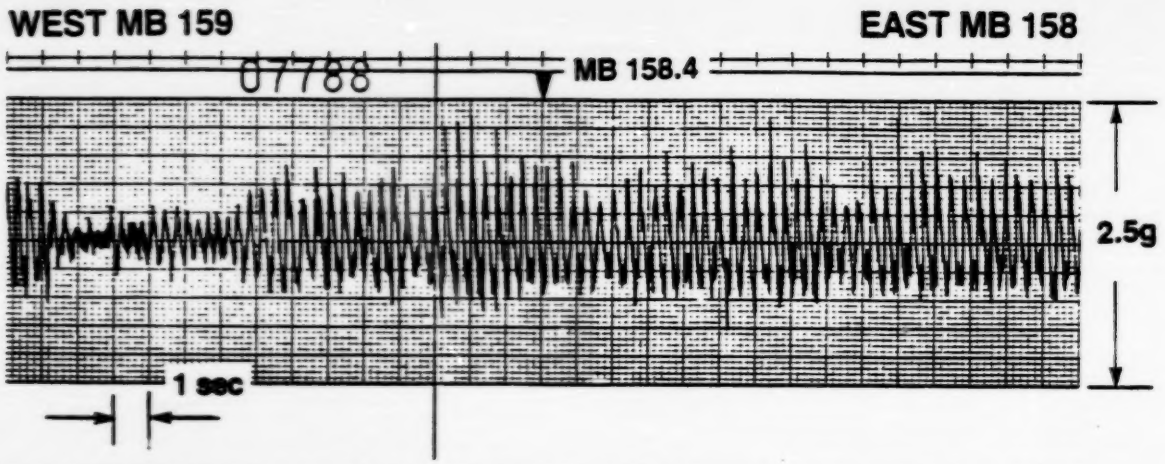
LEADING CARBODY LATERAL ACCELERATION (g) WITH FRAME BRACED TRUCKS



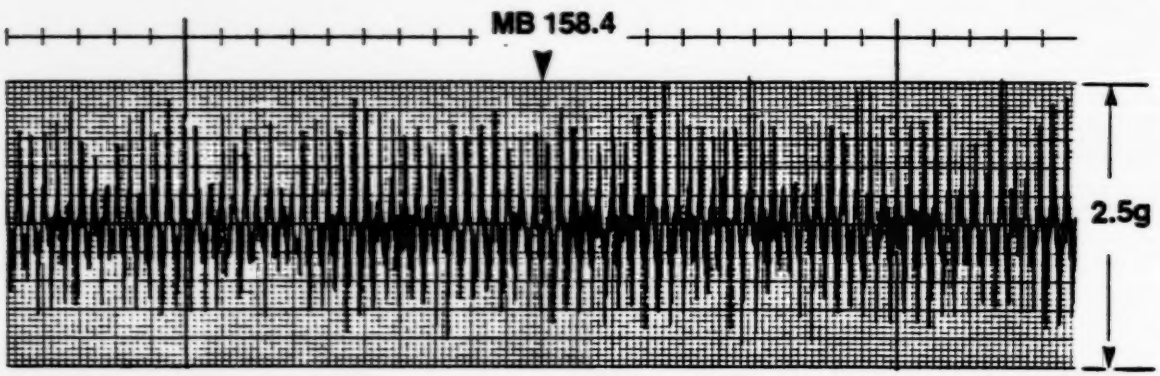
TRAILING CARBODY LATERAL ACCELERATION (g) WITH FRAME BRACED TRUCKS

LATERAL BODY ACCELERATION OF COAL CAR CP 352258 WITH CONVENTIONAL AND UTDC FRAME BRACED TRUCKS RUNNING AT 60 mph BETWEEN MILE POST 159 AND 158 ON THE BROOKS SUBDIVISION

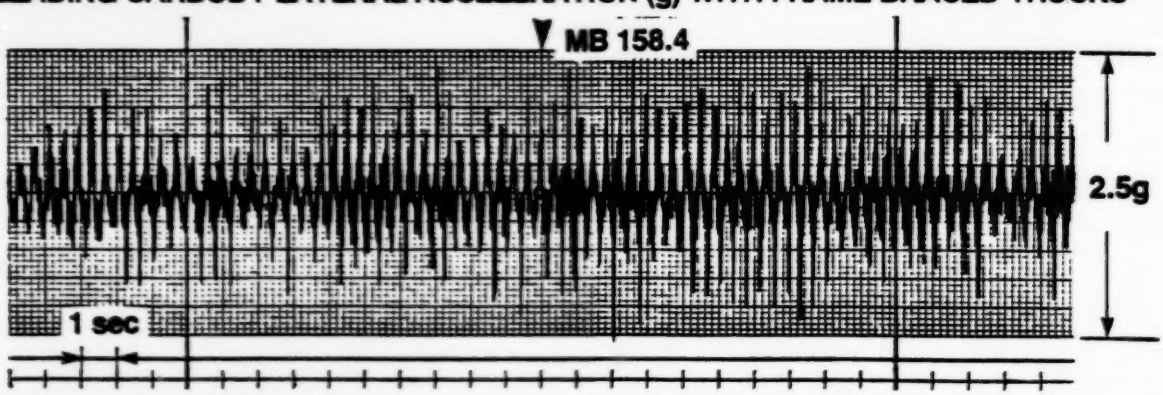
Figure 6



LEADING CARBODY LATERAL ACCELERATION (g) WITH CONVENTIONAL TRUCKS



LEADING CARBODY LATERAL ACCELERATION (g) WITH FRAME BRACED TRUCKS



TRAILING CARBODY LATERAL ACCELERATION (g) WITH FRAME BRACED TRUCKS

LATERAL BODY ACCELERATION OF COAL CAR CP 352258 WITH CONVENTIONAL AND UTDC FRAME BRACED TRUCKS RUNNING AT 65 mph BETWEEN MILE POST 159 AND 158 ON THE BROOKS SUBDIVISION

Figure 7

UTDC BODY

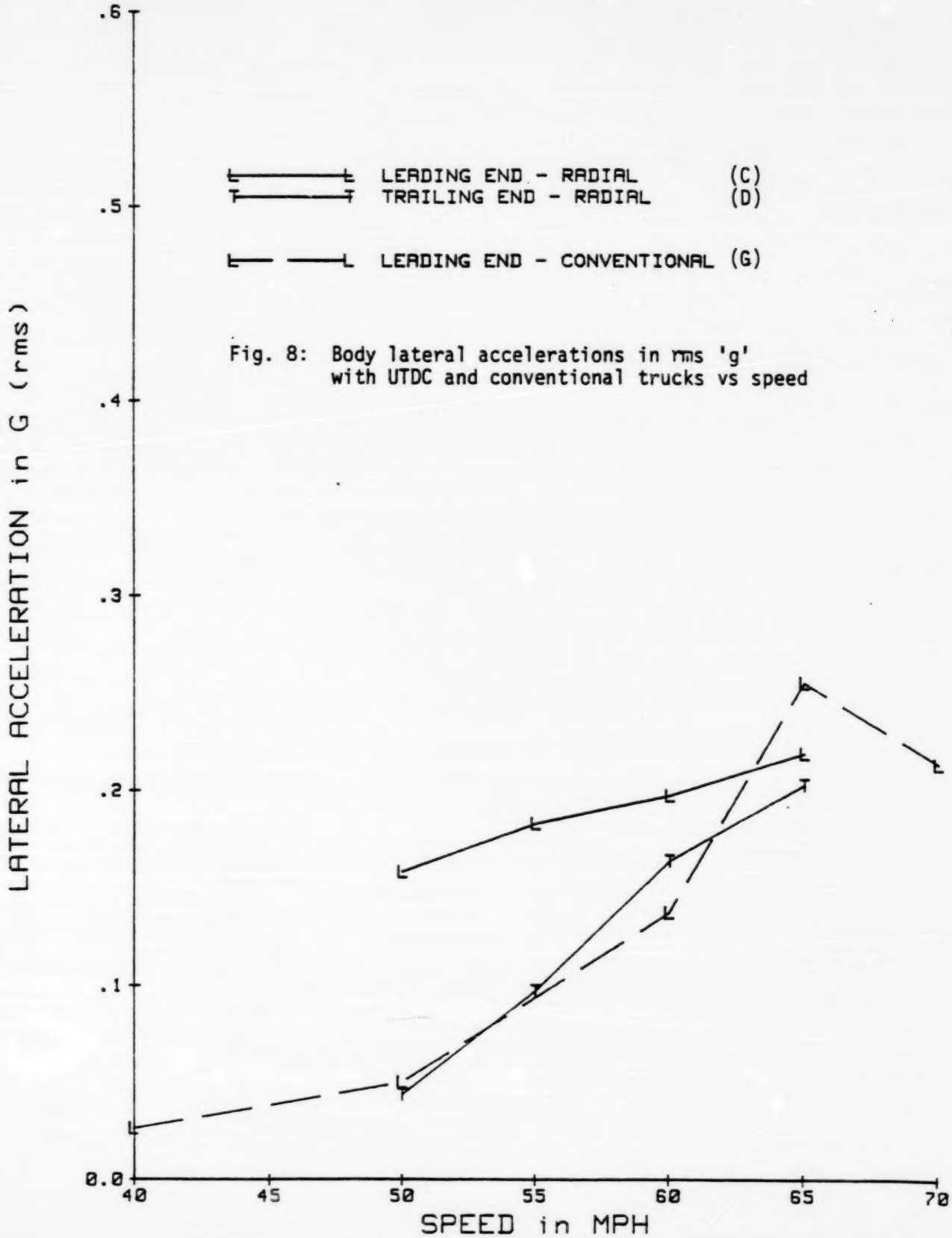


Fig. 8: Body lateral accelerations in rms 'g' with UTDC and conventional trucks vs speed

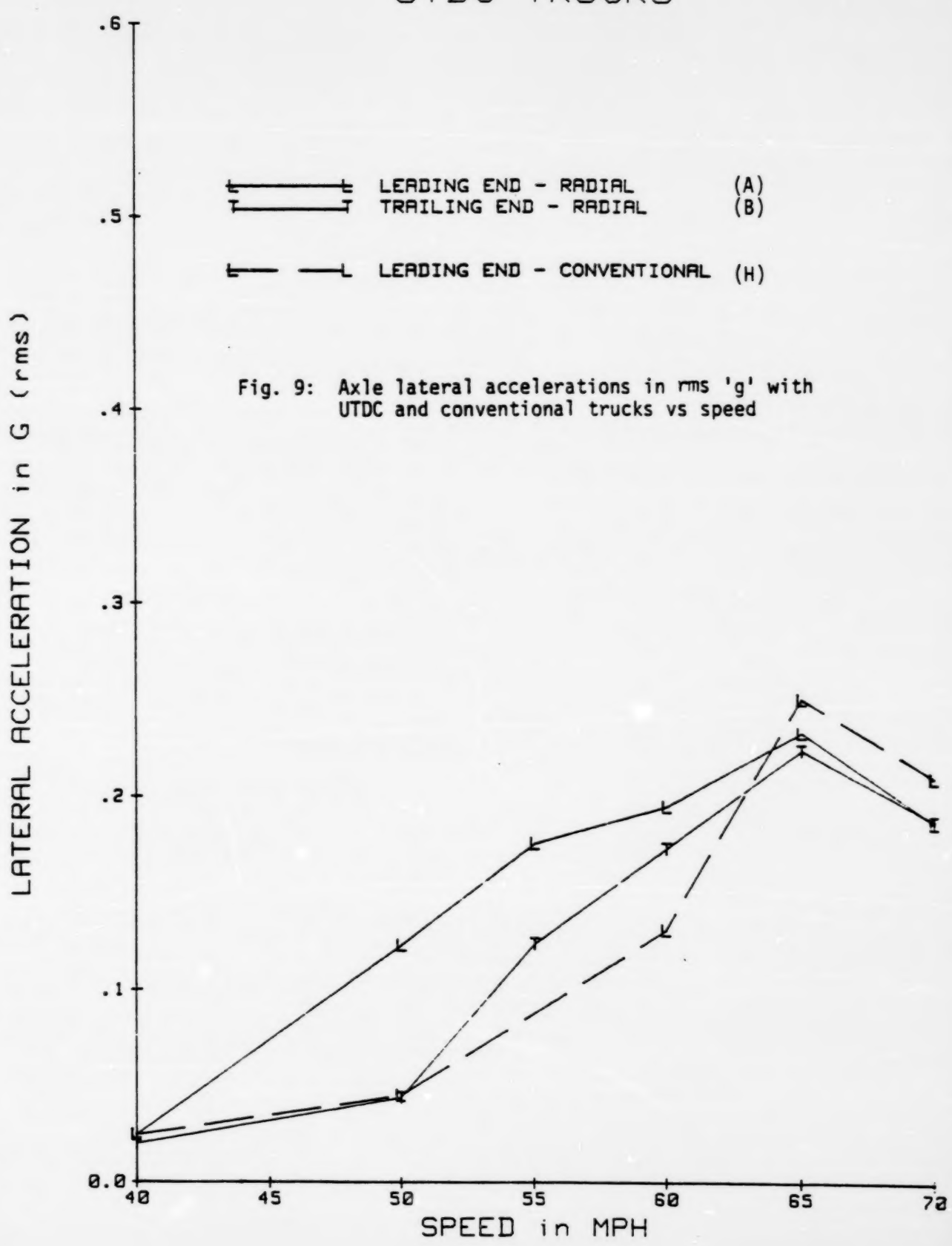


Fig. 9: Axle lateral accelerations in rms 'g' with UTDC and conventional trucks vs speed

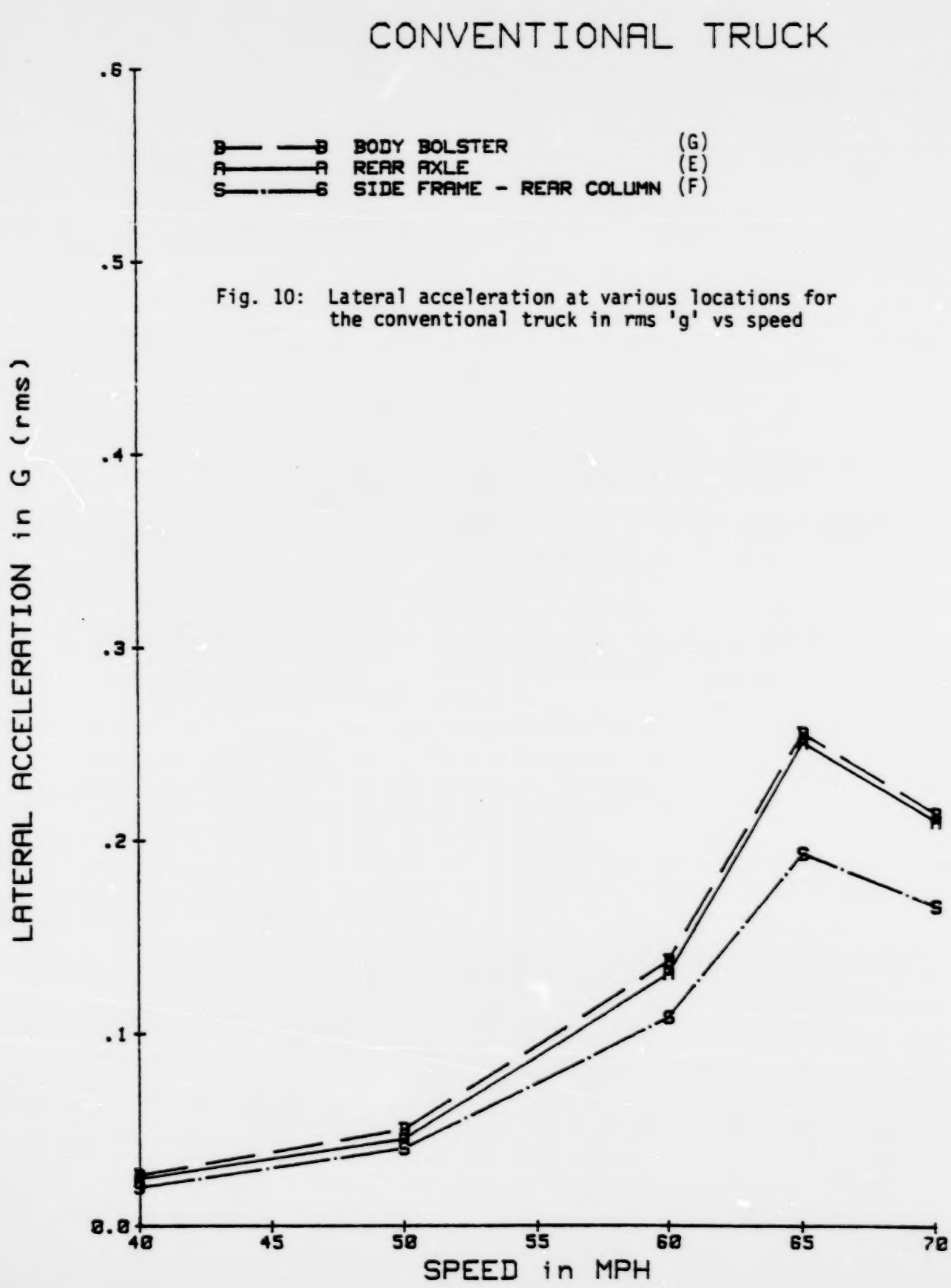
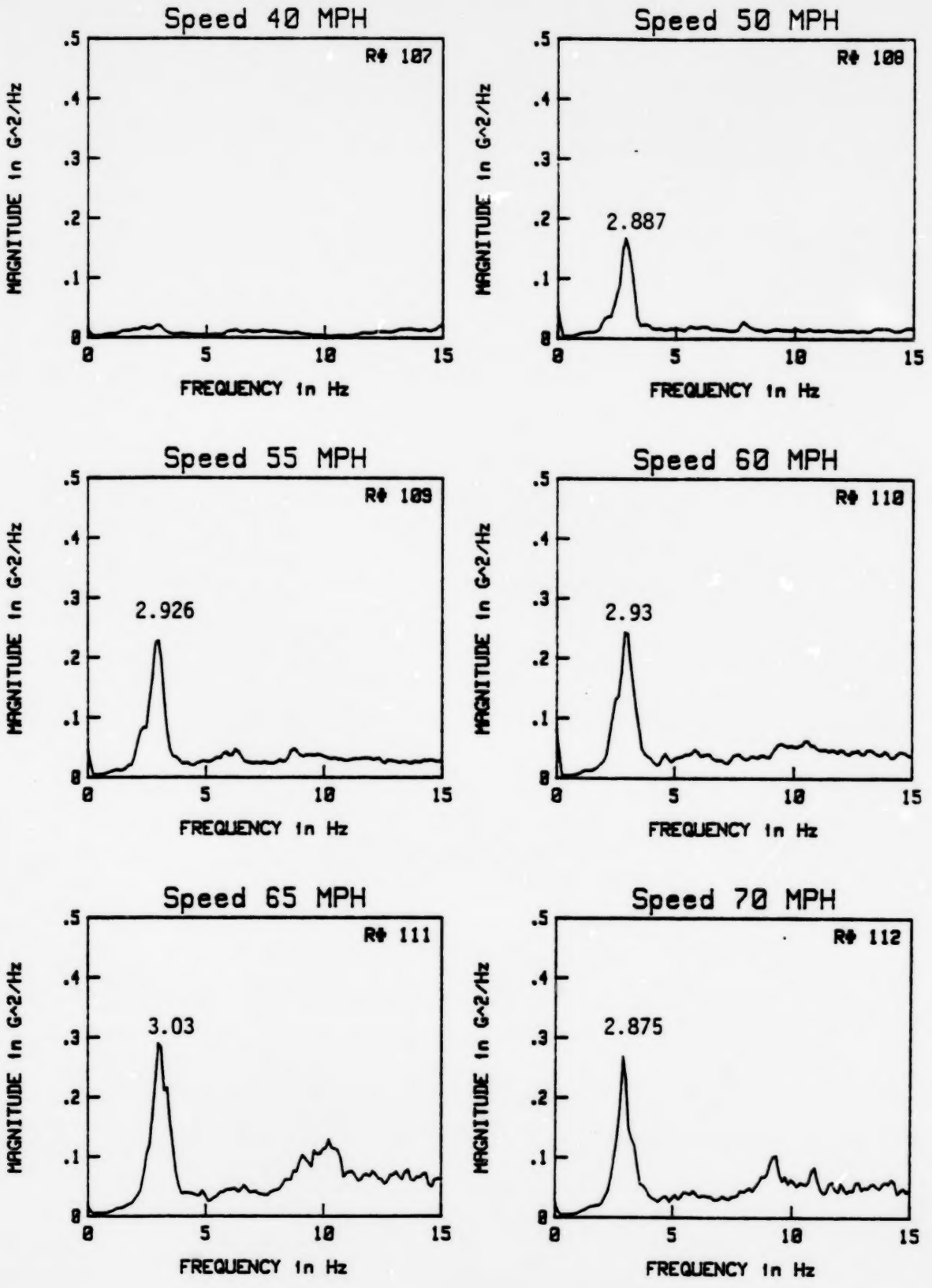


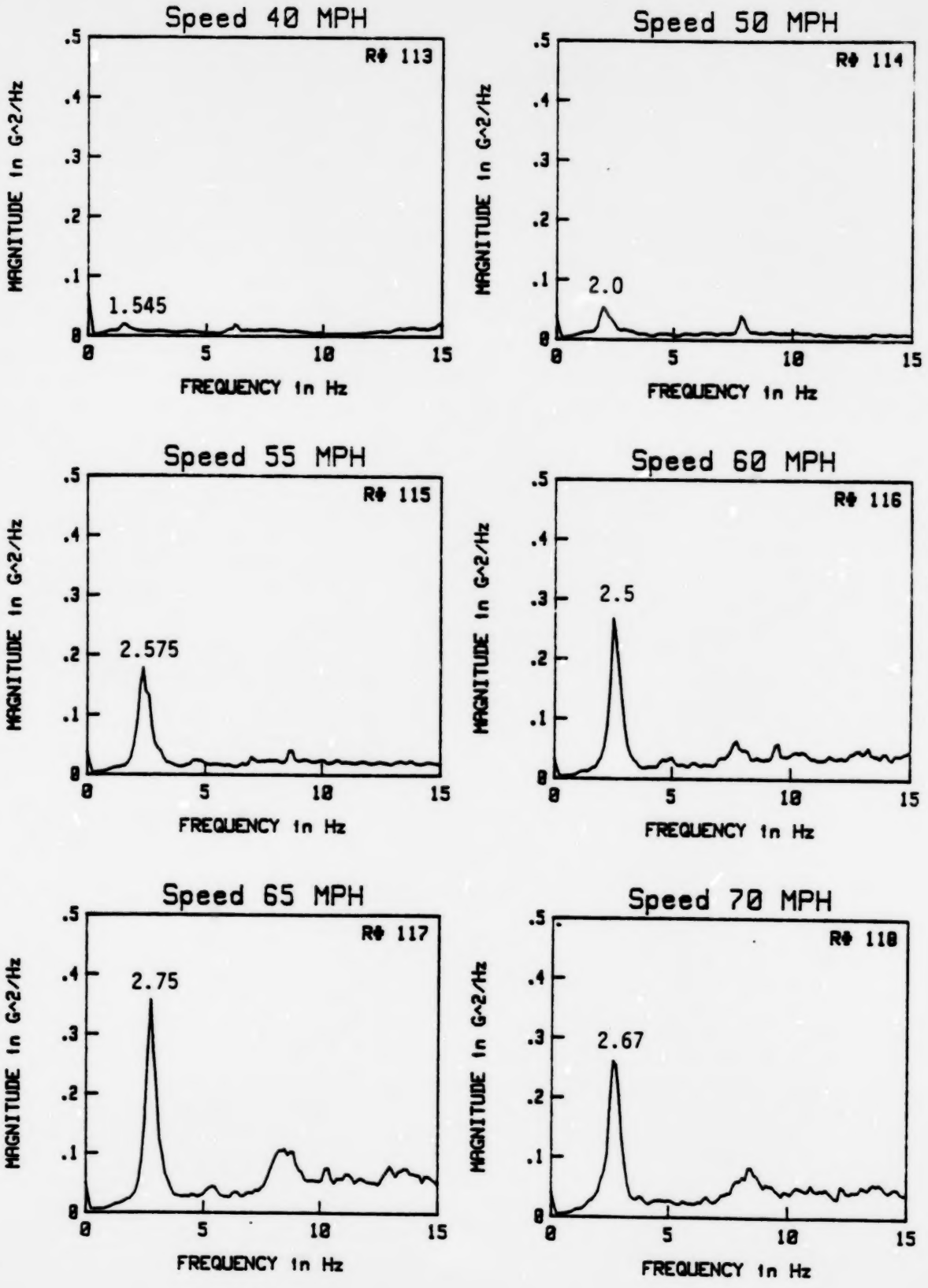
Fig. 10: Lateral acceleration at various locations for the conventional truck in rms 'g' vs speed

Appendix A

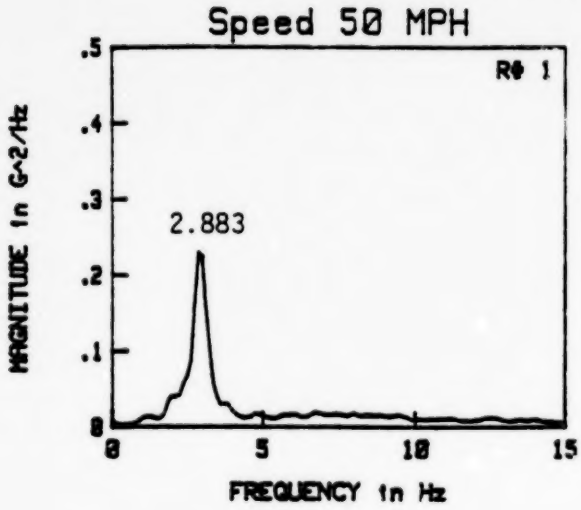
Power Spectral Density Plots of All Lateral Accelerometer Data at Different Test Speeds

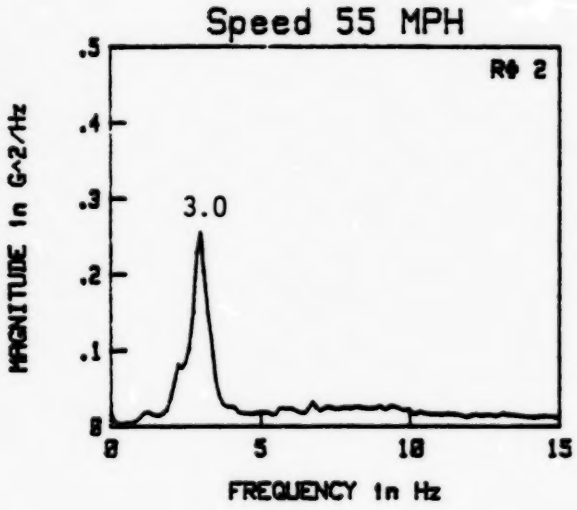


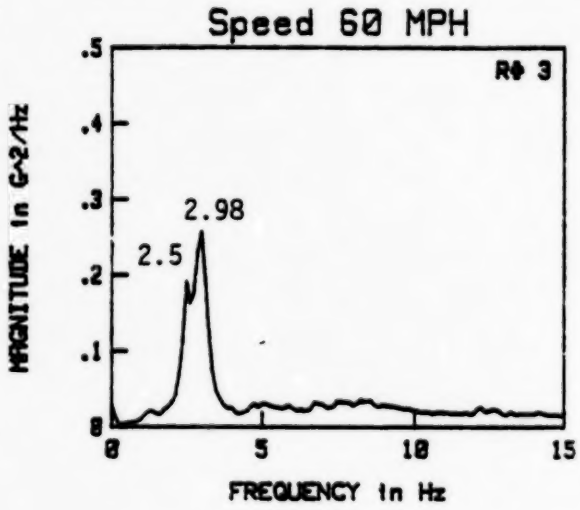
UTDC LEADING TRUCK (RADIAL)

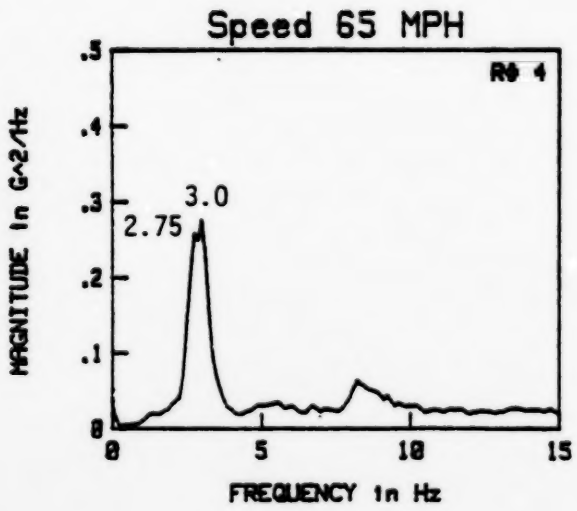


UTDC TRAILING TRUCK (RADIAL)

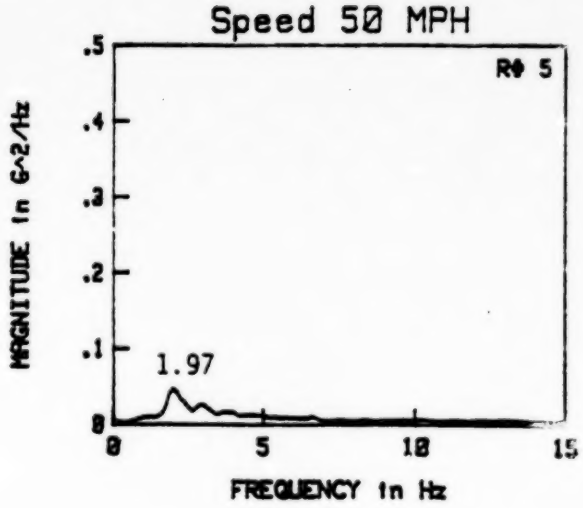


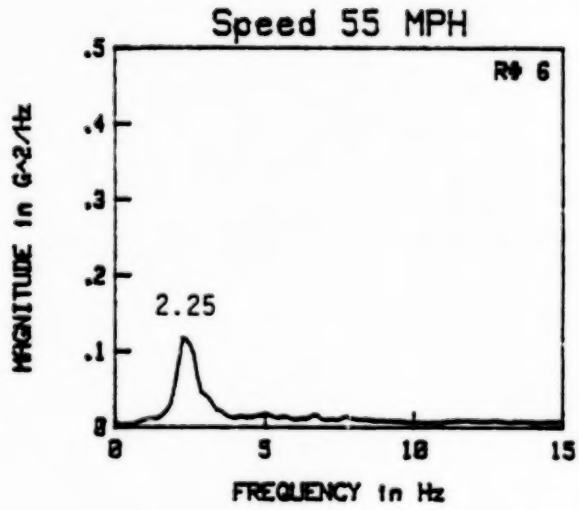


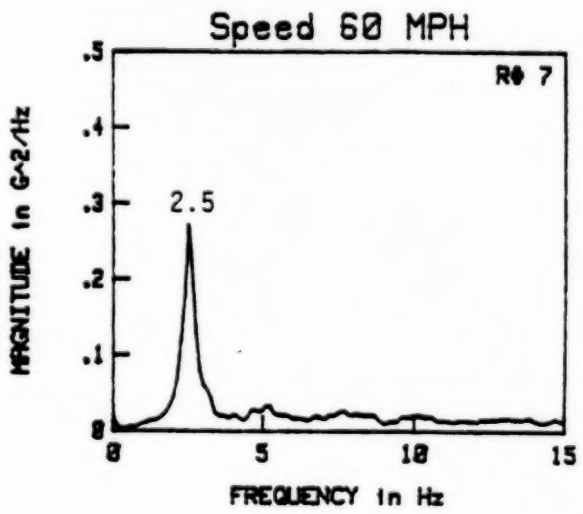


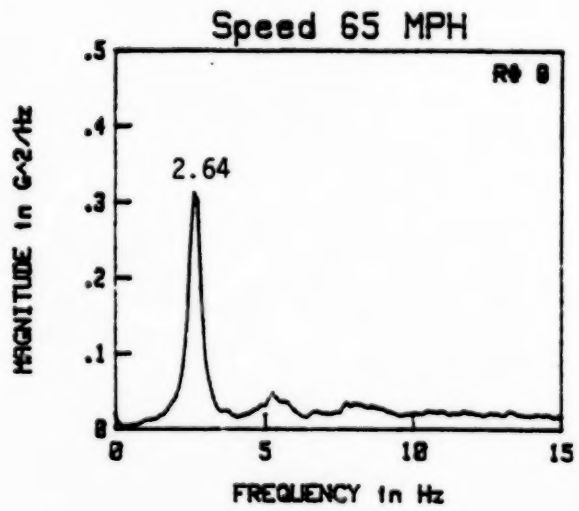


UTDC LEADING BODY (RADIAL)

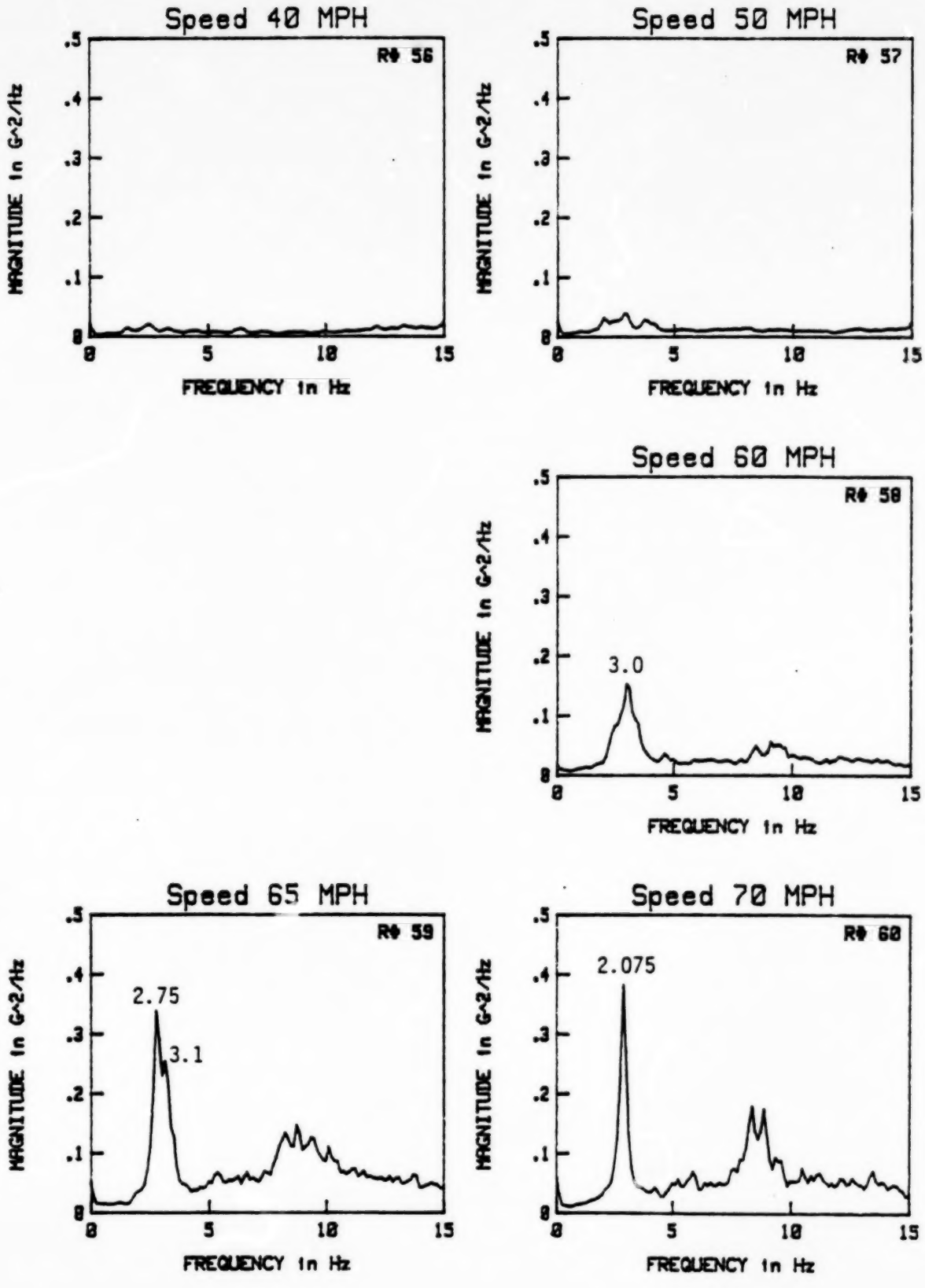




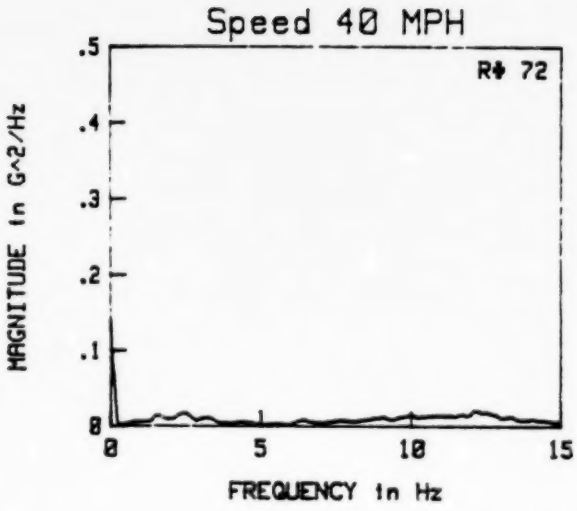


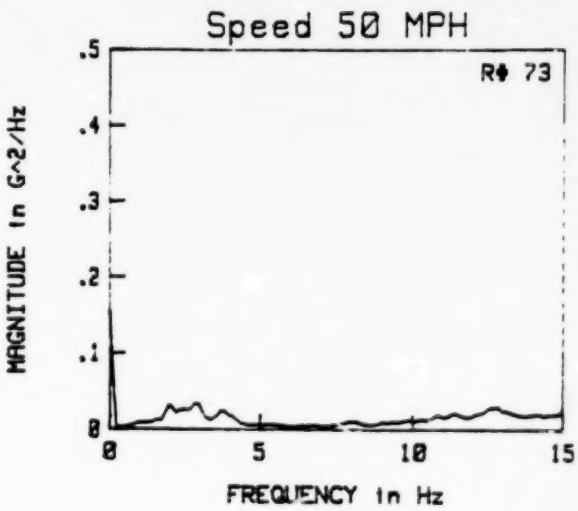


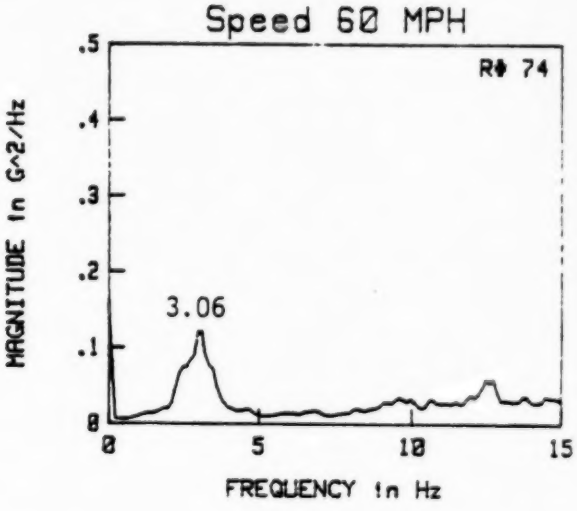
UTDC TRAILING BODY (RADIAL)

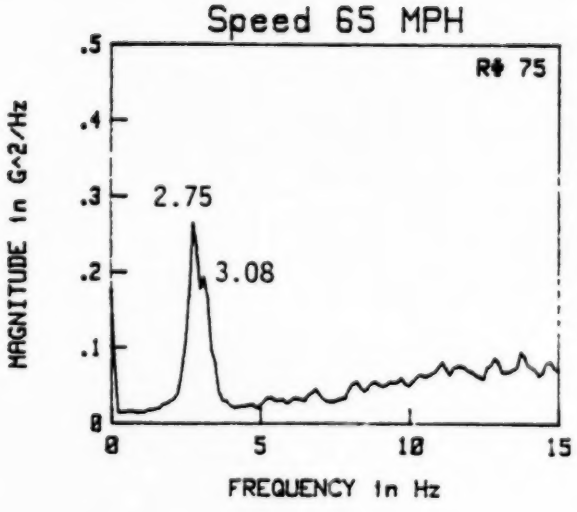


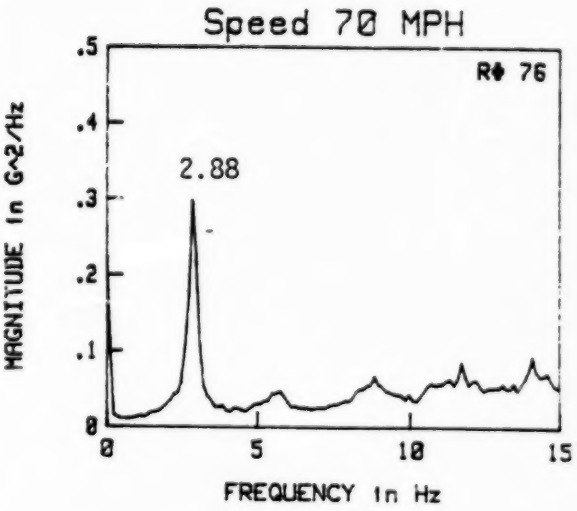
LEADING TRUCK (CONVENTIONAL)



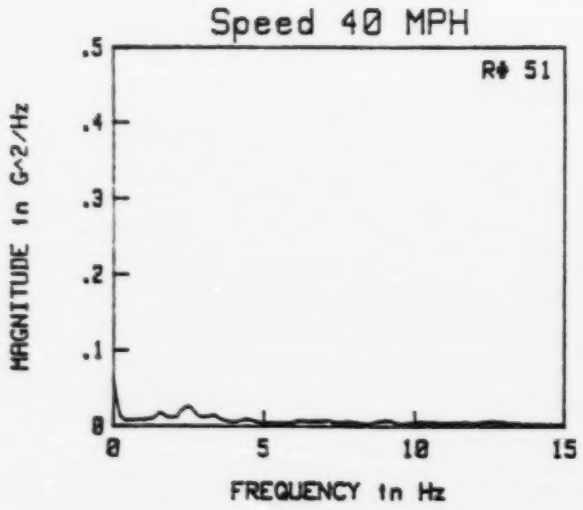


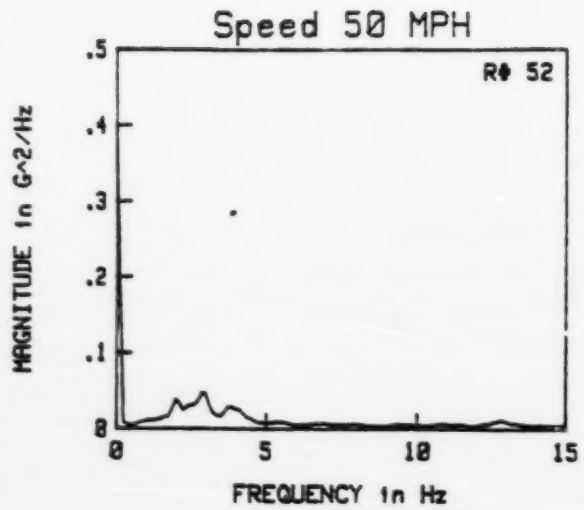


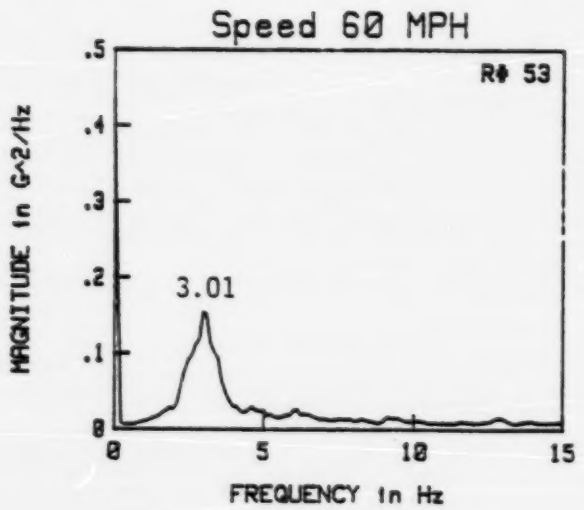


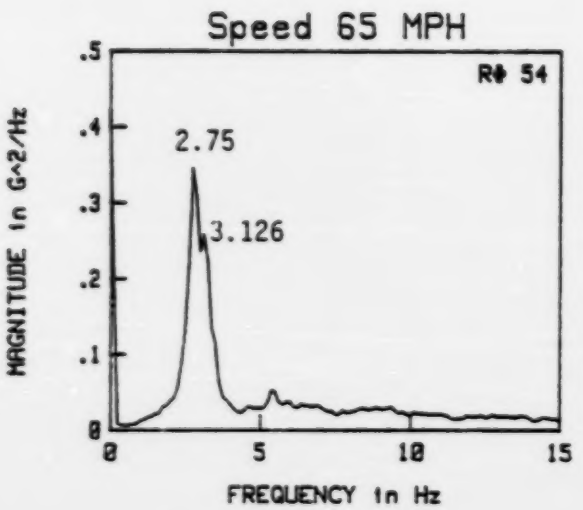


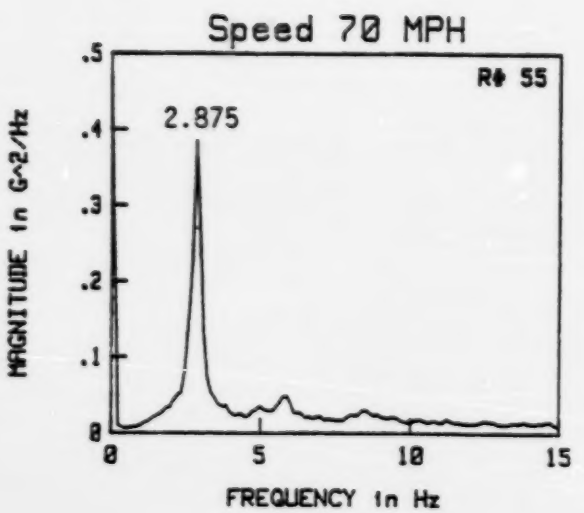
LEAD TRUCK SIDE FRAME (CONVENTIONAL)



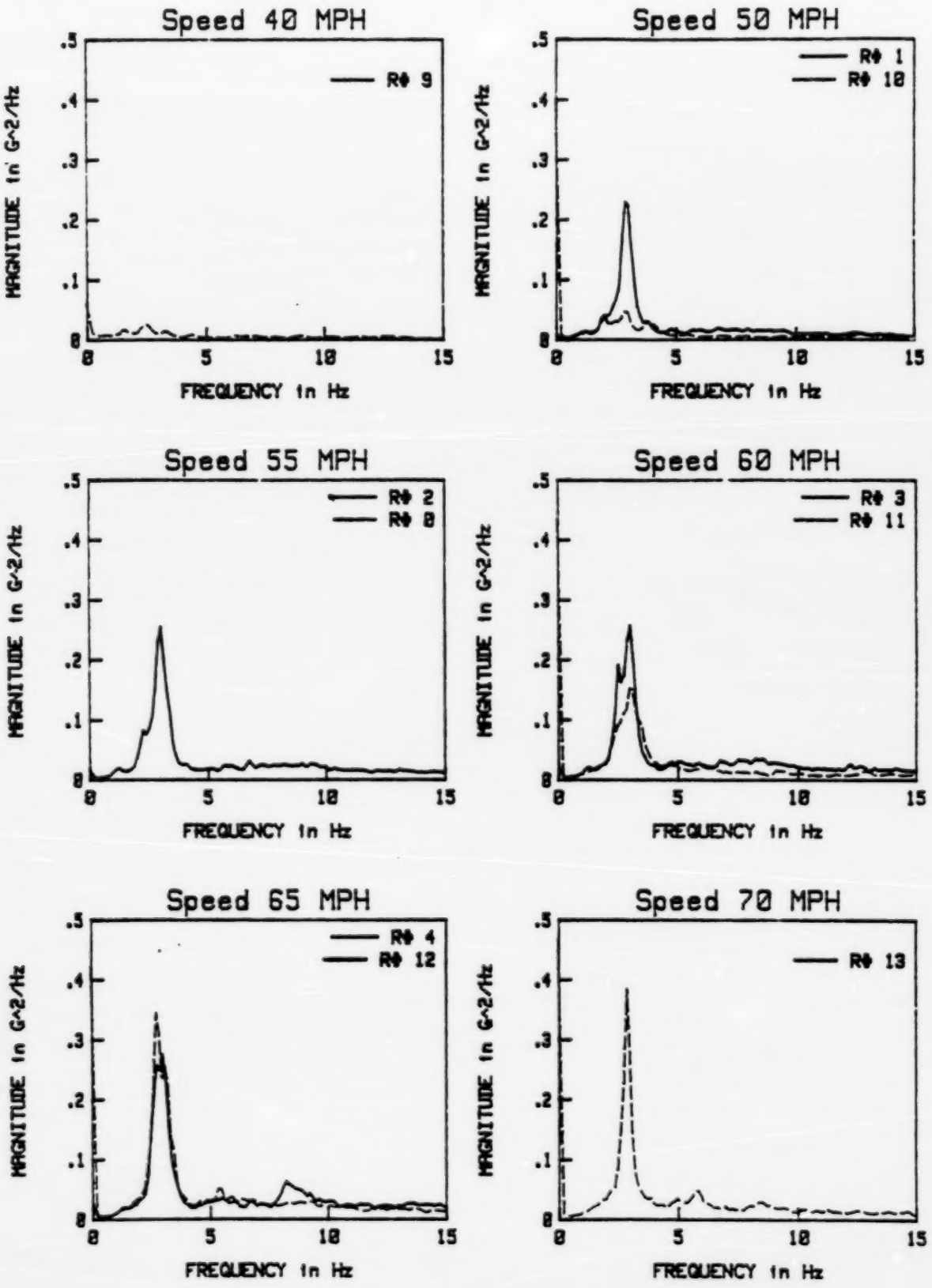




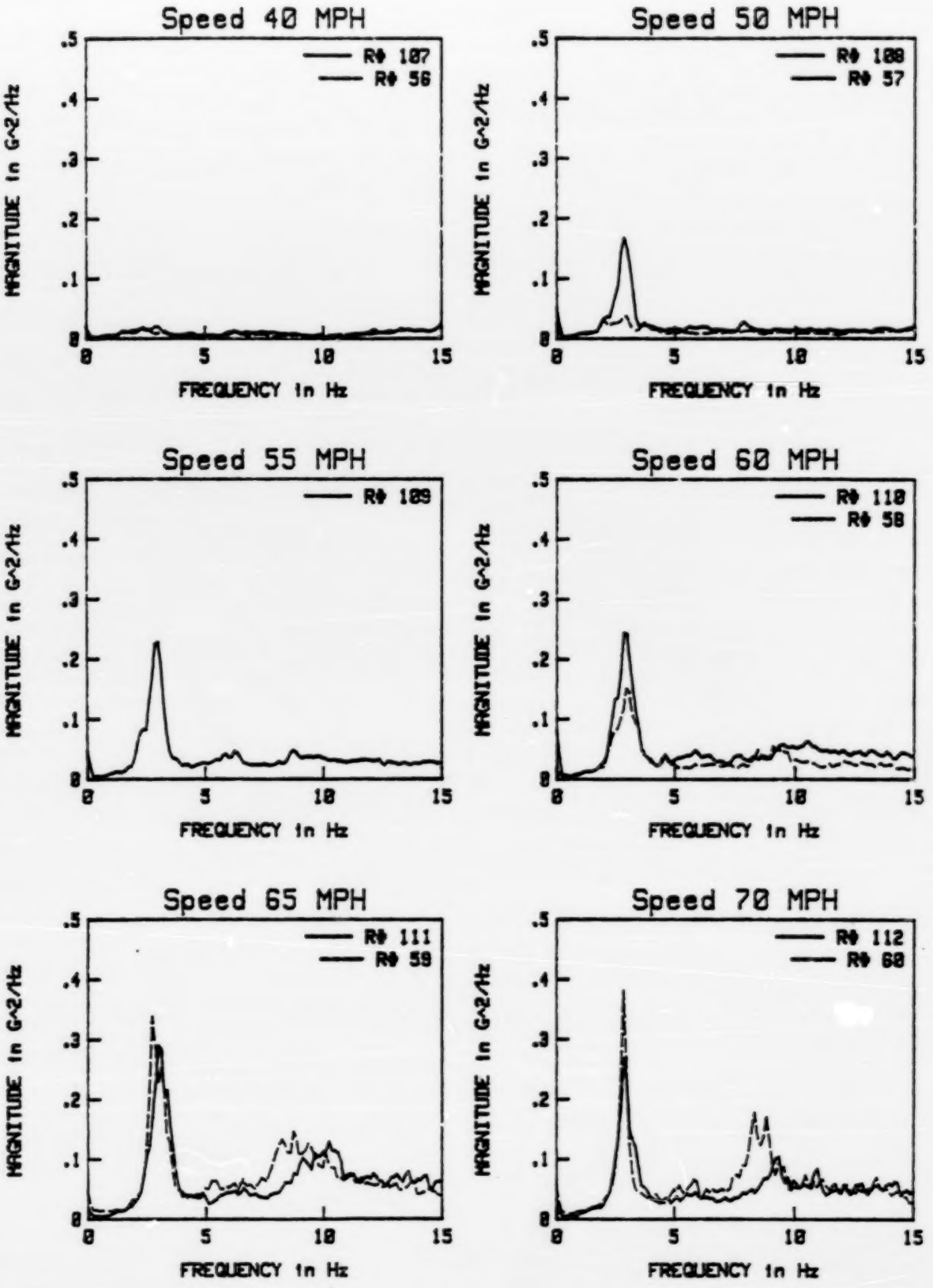




LEADING BODY (CONVENTIONAL)



UTDC LEAD BODY - RADIAL & CONVENTIONAL(dash)



UTDC LEAD TRUCK - RADIAL & CONVENTIONAL(dash)

IN-SERVICE EVALUATION OF UNIT COAL TRAIN WITH RADIAL TRUCKS
- PROGRESS REPORT -

V. Khatchadourian
Research and Development
CP Rail
July, 1986

The results of wheel wear evaluation of Barber-Scheffel and DR-2 trucks indicated that these 100-ton radial trucks will yield substantial savings in wheel flange wear and to a lesser extent savings in wheel tread wear.

CP Rail has now introduced a unit coal train equipped with radial trucks to service. Tests are being planned to evaluate the performance of this unit coal train equipped with the Barber Radial and DR-2 trucks as compared to one equipped with conventional Barber S2-HD trucks. The following tasks have been developed for testing of this trainset now operating on the Pacific Region:

1. Rail Wear: Determine the savings in rail wear which would result from the use of radial trucks.
2. Wheel Wear: Ensure that the wheel wear savings on the radial truck equipped trainset are consistent with those previously measured on wheels of the Barber-Scheffel and DR-2 trucks.
3. Train Energy: Determine the fuel savings which may be realized by the use of radial trucks.
4. Stability Performance: To assess the relative stability of Barber Radial and DR-2 trucks with service worn wheels.
5. General Maintenance Monitoring: Ensure, by regular inspection, that the performance of various components of the radial trucks is adequate.